CHRISTIAN FAITH IN AN AGE OF SCIENCE

CHRISTIAN FAITH IN AN AGE OF SCIENCE . . . .

BY

WILLIAM NORTH RICE, Ph.D., LL.D.
Professor of Geology in Wesleyan University

SECOND EDITION

NEW YORK
A. C. ARMSTRONG AND SON
3 & 5 West 18th Street, near 5th Avenue
1904

Published December, 1903

SECOND PRINTING, MAY, 1904

Printed by
EATON & MAINS, New York, U. S. A.

PREFACE

In my student days I became deeply interested in the relations of science and religion, and in the tentative and provisional solution of the problems which the advance of science offers to religious thought. The sympathy I have felt with the perplexities of successive classes of students, in an experience of more than thirty years as a teacher of geology and the cognate sciences, has kept the subject ever before my mind. The thought of many years finds expression in the present volume.

I have ventured to hope that the book may be useful to several classes of people. To some of my brethren in the church, and particularly in the ministry, who have a hardly adequate appreciation of the value of the contribution which science has made to the world's thought, I have hoped that these pages may bring a more generous appreciation of the results of science, and a greater tolerance of those modifications of religious belief which seem necessary to most scientific men. To some of my associates in scientific work, who may have come to suspect that Christianity is a mere survival from an unscientific age, I have hoped to show that the Man of Nazareth has still a message even for those who rejoice in the discovery and possession of

the new worlds of truth revealed by modern science. Above all, I have hoped to be of service to the same class with whose perplexities I have sympathized, whose doubts I have sought to resolve, and whose enthusiasm for truth has been to me an inspiration, in my life as a teacher. I have hoped that this book may help some young men and women, reared in Christian homes and still cherishing the religious life which grew up amid the associations of their childhood, to feel a stronger confidence that the old heritage of Christian faith need not be lost, in gaining the new treasures of science whose acquisition is the joy of their student days.

No attempt has been made to furnish a complete bibliography of the wide range of subjects treated in the book. Some references have been given, however, to acknowledge indebtedness for a fruitful thought, or to adduce an authority for some fact or opinion which has not yet become a part of the commonplace of science. Other references have been given for the convenience of readers who may desire fuller and more detailed information on some of the subjects briefly treated in this work. As the book is intended for general readers rather than for specialists, I have not been particular to refer to the original sources, but have aimed to refer to books that are easily accessible. With very few exceptions the references are to books in the English language.

Although the present work is essentially new, it contains a small amount of material which has been pre-

viously published. Certain portions are taken with little alteration from a book entitled "Twenty-five Years of Scientific Progress, and Other Essays." Acknowledgment is due to Eaton & Mains for permission to republish the greater part of two articles which have appeared in the "Methodist Review." Acknowledgment is due also to D. Appleton & Co. and to the Open Court Publishing Company for permission to copy a few figures.

My thanks are due to a number of my colleagues in the Faculty of Wesleyan University for information kindly furnished, supplementing my meager knowledge of some subjects which the plan of the work made it necessary to treat. In conclusion, I take pleasure in acknowledging the assistance of my brother, Rev. Charles F. Rice, D.D., and my son, Professor Edward L. Rice, Ph.D., who have read the book in proof, the latter also in manuscript, and who have favored me with valuable criticisms.

CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

No revolution in the intellectual and moral life of mankind is comparable with that which was wrought by the influence of the life and teaching of Jesus of Nazareth. The contrast between the stupendous result and the apparent feebleness of the means by which it was effected is amazing. A Galilean peasant, without education, without social position or any other element of worldly power, strolled up and down the land of Palestine, talking of the Heavenly Father and of the kingdom of God. He wrote no book, he developed no system of philosophy, he effected no definite social organization. His teaching aroused the rancorous hostility of the chief priests and other religious leaders of his own people. Their malice brought him to trial before the Roman procurator, and terrorized the procurator into ordering his crucifixion.

The little band of disciples that he left, inspired by their love for him and their faith in his resurrection, entered upon the seemingly quixotic undertaking of converting the world to a new religion. The most conspicuous leaders of this little band were a group of fishermen whom Jesus had called from their nets on the shore of Galilee. A quarter of a century later

it was said of the body of Christians, "Not many wise men after the flesh, not many mighty, not many noble are called." Among the original apostles there was not one whom the world would have reckoned as wise or mighty or noble. From the very beginning, the chief priests and religious leaders of the Jews cherished a violent hostility to the new sect, and employed against its members such measures of persecution as they were able to practice in their condition of political dependence. Outside the pale of the Jewish nation the body of Christians was for a time protected by its very insignificance; but, as the church increased in numbers, it provoked antagonism. It came into conflict with a polytheistic religion, enshrined in poetry whose beauty the world will never outgrow, incarnated in sculpture whose fragmentary relics are the admiration of mankind. It found the polytheistic faith intertwined with all social and political institutions, so that refusal to conform to the rites of the popular religion ostracized the Christians from society, and exposed them to the penalties involved in disobedience to the laws of the state. In seeking dominion over the minds and the conduct of men, the new religion came into competition not only with the popular religion, but also with systems of philosophy in which some of the world's greatest thinkers had sought to solve the mysteries of life and destiny. The new religion encountered the contempt of the learned and the hatred of the vulgar. The tremendous power of the Roman empire was exerted for its suppression. Persecution

unto death threatened the Christians, now from the violence of mobs, now from the severity of legal tribunals. The Roman populace amused itself with their dying agonies, as they fought with lions in the arena; and, clothed in pitchy shirts, their bodies flamed as ghastly torches to light up the gardens of Nero.

Yet Christianity pursued its resistless way, and in less than three hundred years after the death of its founder it had become a legalized religion throughout the Roman empire. In the year of our Lord 313, the edict of Constantine and Licinius repealed all statutes against the Christians, and gave full toleration to the new faith. The Galilean had conquered.

It must be supposed that Christianity thus won its way, in spite of all opposing forms of religious and philosophic belief, because, in the light of such knowledge as the world then possessed, it appeared to be probably true. Not, indeed, that then, or at any other time, were men's opinions purely logical, in the sense of being formed by a purely intellectual process of weighing of evidence. The progress of Christianity was unquestionably due largely to emotional influences. The pitying admiration with which multitudes beheld the calm fortitude and forgiving meekness of the martyrs doubtless made many converts to Christianity. But there was a sound, though unformulated, logic in such play of feeling, for there is a strong presumption that a faith whose fruit is transcendent goodness is rooted in essential truth. But, however the intellectual processes of men may be modified by emo-

tional excitement, it is broadly true that the opinions of masses of men, though never wholly rational, are never wholly irrational. We must therefore suppose that, in the light of all the knowledge then available, the evidences of Christianity were such as to establish its probable truth.

But the intellectual atmosphere of our age is vastly different from that of the first century of the Christian era; and it is a serious question whether the religion whose birth and rapid early growth took place in the intellectual environment of that far-off age can continue to subsist in the very different environment of our time.

The contrast between the first century and the twentieth may be broadly expressed in a single word. That was an unscientific age, this is a scientific age. There was in general little of science even among the philosophers of the ancient world. Some, indeed, there were who manifested in considerable degree the scientific spirit. The works of Aristotle give abundant evidence of careful observation of physical phenomena and sound inductive reasoning based upon such observation. The Museum of Alexandria was the home of a group of investigators whose spirit and whose achievements were truly scientific. But the most of the ancient philosophers were given to *a priori* speculations in regard to the mysteries of existence, rather than to observation of definite phenomena and inductions based thereon.

Moreover, what little science there was in the

schools of philosophers failed to exert any considerable influence upon popular thought. The doctrines of the philosophers were held and taught in esoteric fashion. In the absence of the art of printing, books were rare and costly, and anything like a general diffusion of knowledge was impossible. Nor did the philosophers wish to diffuse their knowledge. They counted philosophic thought the high privilege of a select few, who dwelt apart from the vulgar herd, like the gods of Olympus. The disciples of a philosopher constituted in general a sort of secret society. They were initiated into mysteries which were their exclusive possession. They never dreamed of any obligation to hold the lamp of truth which was given to them so as to illumine the path of common mortals. In part, too, this esoteric habit of the philosophers was necessary for self-preservation. Their views were often more or less in conflict with the teachings of the popular religion, but they suffered no peril while they philosophized in secret and conformed in public to the popular ritual. Had the teaching of philosophy been more public, there might have been other martyrs besides Socrates. Untouched by the influence of science, the popular conception of the universe was largely poetic and mythological. The age when the sunbeams were the golden arrows of Apollo, is very far removed from an age in which we measure the wave-lengths and count the vibrations of light.

Christianity was the heir of Judaism, and its heritage included the Hebrew Scriptures known to us now

as the Old Testament; and the ideas of the natural world which prevailed among the early Christians were essentially those represented in the Old Testament. Exquisitely beautiful often are those Hebrew representations of the universe, full of the richest poetry of nature; but honest exegesis can find there no faintest gleam of the light of science.

On one point there was substantial agreement among learned and unlearned, pagans and Christians; and that was the geocentric constitution of the universe. The earth was the center around which the heavenly bodies revolved, and those bodies were functionally appendages to the earth. A few of the Greek philosophers, indeed, had thought of the sun as the center of the system; but they had no very satisfactory evidence for such an opinion, and with them it was perhaps rather an accidental vagary than a manifestation of surpassing wisdom. Certain it is that there was substantial unanimity in the notion of the central position of the earth. In regard to the form of the earth, the learned generally regarded the earth as round, while the general public held it to be flat. Some of the Greek geometers even reached approximately correct notions in regard to the size of the earth. But popular thought knew nothing of such notions. To the Hebrew people the world was flat, and the heaven was a curtain stretched over it like the roof of a vast tent, supported by mountain pillars around the borders of the earth. From time to time windows were opened in that roof, through which came the fertilizing rains and snows.

The celestial luminaries were the adornments of that great curtain which formed the roof of this earthly tabernacle. The early Christians accepted substantially the old Hebrew conception of the earth.

In the writings of some of the Greek philosophers we find some anticipation of evolutionary ideas, some recognition of the truth that the earth has come to be what it is by a series of gradual changes; but those notions were crude and premature. The mythological cosmogonies were mere vagaries. The conception of the egg from which emerged the universe, and the conception of the primal element of water from which all things were evolved, were alike destitute of any scientific value. Christianity adopted from the Hebrew Scriptures the doctrine of the origination of all things in a series of creative fiats in a literal week a few thousand years ago.

Nowhere was there a conception of dynamic unity in the universe. The conception of the unity of nature can belong only to a comparatively advanced stage of scientific development. To the unscientific mind the processes of nature seem to result from the play of agencies mutually independent and often antagonistic. Polytheism is the natural counterpart of the unscientific view of nature. The Hebrews, unlike the nations around them, were monotheists; but how far the actual faith of the mass of the Hebrew people was a strict philosophic monotheism may be questioned. Apparently, at least in the early stages of Hebrew religion, a practical monotheism coexisted

with a theoretical polytheism. Jehovah was a god so much mightier than all other deities that they deemed it wise to ignore all others and worship him alone. Before the time of the Christian era, however, Hebrew faith seems to have reached the standard of genuine monotheism. But, though monotheistic faith gives to nature a sort of unity, as being all the work of one Creator, the Hebrew conception of God was too grossly anthropomorphic to lead to any such thought of the unity of nature as modern science has developed. A God subject to human fickleness and caprice could form no comprehensive plan whose expression in nature would be changeless law. Nowhere in the first century was there any such faith as the world has now reached in the uniformity of nature or the constancy of natural law. Miracles or prodigies could be accepted without investigation, and on the slightest evidence of testimony, as though they were as credible as the most ordinary facts. The flippant, self-indulgent Herod could believe that John the Baptist, whom he had murdered, had risen from the dead; and widely diffused among the Roman populace was the belief that Nero would return from the realm of shades to curse the world again with his presence.

The change in the view of nature wrought by modern science involves three specially important ideas:

1. The extension of the universe in space, and the heliocentric constitution of the solar system. The heavenly bodies are not mere appendages of the earth, insignificant in size, and revolving at a short distance

from the earth. They are great worlds distributed through space at immense distances; and, of that sisterhood of worlds to which our earth immediately belongs, the sun and not the earth is the center.

2. The extension of the universe in time. The universe has come to be what it is by a long series of changes, and the earth and the heavens contain monuments wherein the stages of that history are recorded.

3. The unity of the universe. Through all the seeming chaos of phenomena runs one all-pervading, all-controlling system of law. The discovery of universal gravitation was the beginning of the conception of dynamic unity in the universe; and in later time the idea of the unity of the universe has found its completest expression in the doctrine of conservation of energy and in the doctrine of evolution, the one ascribing to the universe a unity of force, and the other ascribing to it a continuity of development.

The question, then, before us is whether Christianity can survive the prodigious change which has taken place in the intellectual environment. It is obvious that so great a change in the knowledge and thought of the world must involve changes in many beliefs more or less closely connected with Christianity. An alleged miraculous event is necessarily regarded in a very different light at the beginning of the twentieth century from that in which it was regarded in the first century. The miraculous character of a narrative was then no reason why any one should fail to believe it. In this age of scientific thought, every alleged miracle

labors under a heavy burden of *a priori* improbability. There may be sufficient reason for accepting certain miracles as historic, but they can no longer be accepted in the unquestioning way which once was possible. The status of miracle in relation to scientific thought is of special importance, since one alleged miracle—the resurrection of Jesus—is not an incidental fact connected with Christianity, nor merely an evidence of Christianity, but an integral part of Christianity. The denial of the resurrection of Jesus would involve a radical reconstruction of Christian doctrine.

In the Gospel according to Luke, and in the Acts of the Apostles, we are told that Jesus led his disciples to the Mount of Olives, and that, after talking with them, "he was taken up, and a cloud received him out of their sight."* Those men accordingly saw, or thought they saw, the body of Jesus ascending vertically from the earth until it was hidden from them by a cloud. It is not necessary for us here to discuss how far their impression corresponded to objective fact, and how far it was merely subjective. Whatever they saw, or thought they saw, the phenomenon had one meaning to men who supposed that directly above the flat and stationary earth, and beyond the cloudy expanse of the firmament, was the throne of God; and it must have a very different meaning to men who believe that the earth is whirling through space at a rate of eighteen and one half miles per second, and that the direction of the zenith changes hourly through an angle

* Acts, i, 9.

equal to 15° multiplied by the cosine of the latitude. This story of the ascension is a very striking illustration of the truth that the progress of science renders inevitable some change in the beliefs that have been considered an integral part of Christianity. The question is whether the necessary changes can be made, and the essentials of Christian faith preserved. Can Christianity be so modified as to bring it into harmony with the new environment? or must it share the fate of all ill-adjusted organisms, and become extinct?

The discussion before us will be divided into three parts.

In the first part, we shall pass briefly in review the history of those scientific discoveries which have resulted in developing the three characteristic ideas of the extension of the universe in space, the extension of the universe in time, and the unity of the universe. The history will be sketched in an order partly chronological and partly logical. In connection with each series of scientific discoveries we shall consider what changes those discoveries have necessitated in Christian doctrine.

In the second part, we shall consider the status of certain doctrines of Christianity, in relation, not to a single scientific discovery, but to the general intellectual atmosphere which the progress of science has developed.

In the third part, we shall consider the general status of Christian evidence in relation to the intellectual atmosphere of a scientific age.

This treatment of the subject will necessarily involve some repetition; as it will be necessary to discuss somewhat systematically in the second part certain doctrines to which reference is made more or less extensively in the first part, and those scientific discoveries whose history is sketched in the first part, must from time to time be referred to in the second and the third part. It is believed, however, that this order of treatment is justified by sufficient reasons in spite of this obvious objection. It is needless to say that the first part of the discussion will be chiefly scientific, the second and third parts chiefly theological.

PART I

HISTORY OF SCIENTIFIC DISCOVERIES WHICH HAVE AFFECTED RELIGIOUS BELIEFS

PART I

History of Scientific Discoveries Which Have Affected Religious Beliefs

I.—The Extension of the Universe in Space*

THE approximately spherical form of the earth was clearly recognized by Aristotle and others of the Greek philosophers, and some of the ancient geometers had even reached approximately correct notions of the size of the earth. The arguments which led the scientists of classical time to a belief in the approximately spherical form of the earth were substantially the same whose validity is recognized in the thought of to-day, except that the experimental proof afforded by the circumnavigation of the globe was yet many centuries in the future. Attention was called by the ancient astronomers to the change in the elevation of the pole star in journeying northward or southward, and to the fact that in such a journey some stars are lost to view behind the traveler, while others become visible before him. The circular outline of the shadow

---

*The history of astronomy from Hipparchus to Newton is given with great fullness in Whewell, *History of the Inductive Sciences*. A brief and interesting sketch of the main features of the history is given in Cooke, *The Credentials of Science the Warrant of Faith*. See also article on *Astronomy*, by Proctor, in *Encyclopædia Britannica;* Lodge, *Pioneers of Science*.

of the earth cast upon the moon in a lunar eclipse was also recognized as a cogent argument for the sphericity of the earth. But, while the Greek philosophers recognized the evidence of the rotundity of the earth, the belief of the mass of the population was undoubtedly that the earth was flat. The Christian church in its early days for the most part accepted the latter view, in accordance with the implications of the Hebrew Scriptures. But, during the centuries which intervened between the founding of the Christian church and the epoch of great maritime discoveries at the close of the fifteenth and the beginning of the sixteenth century, both opinions were held in the Christian church. The belief in the sphericity of the earth, though not the belief of Christian people in general, was held by learned men in the church, and was tolerated. The proof which finally brought a practically universal acceptance of the doctrine of the sphericity of the earth was furnished by the great voyages of discovery. In 1492 Columbus reached the West Indies by journeying westward from Spain. In 1498 Vasco da Gama rounded the Cape of Good Hope, and sailed through the Indian Ocean till he reached the shores of India. But it was not till 1522 that the consummate feat of circumnavigation of the globe was accomplished. In that year one of Magellan's ships returned to Spain, after a voyage of three years, in which it had found the way into the Pacific through the strait whose name commemorates the achievement, traversed the whole extent of the Pacific, and

rounded the Cape of Good Hope; though the intrepid commander of the expedition had been killed in the Philippine Islands. The result of that voyage was the universal recognition of the sphericity of the earth. To men destitute of the spirit of science, who formed their opinions in what they supposed to be the light of common sense, the circular outline of the darkened area on the eclipsed moon might seem evidence all too shadowy to justify a belief which seemed to contradict the common experience of mankind; though faith in that shadow sustained the strong soul of Magellan through all the fearful hardships of that memorable voyage. But even men of common sense could not resist the evidence which was furnished by the circumnavigation of the globe.

While there was difference of opinion between the ignorant and the learned in ancient times in regard to the form of the earth, there was practically no difference in regard to the position of the earth relative to the other bodies of the universe. The geocentric constitution of the universe was accepted with substantial unanimity. Before considering the series of discoveries that led to a change from the geocentric to the heliocentric conception of the solar system, let us consider the facts in regard to the apparent movement of the heavenly bodies, and the way in which those facts were explained by the Greek astronomers. Every one has observed that the whole celestial sphere—the sun, moon, and stars—appears to revolve around the earth from east to west, so that each of the heav-

enly bodies appears to rise in the east, and, after passing across the sky, to vanish below the horizon in the west. It was, however, very early observed that seven of the celestial bodies which are large enough and near enough to be seen with the naked eye, have a movement independent of that general movement of the celestial sphere. The sun, the moon, and the five planets, Mercury, Venus, Mars, Jupiter, and Saturn, were observed to change their place with reference to the other bodies, the so-called fixed stars. The appearance is that, while the celestial sphere as a whole revolves around the earth from east to west in every twenty-four hours, these seven wanderers have a slower independent revolution from west to east. Closer study of the apparent movements of these bodies showed that their apparent revolution from west to east within the celestial sphere is executed with unequal velocity. In fact, in the case of the five planets, the movement is not even constant in direction. They seem to move for a certain time from west to east, and then to stop and move for a time from east to west, though the net result of the movement which they have, independent of the general movement of the celestial sphere, is a revolution from west to east This irregularity in the velocity and the direction of the movement of these planets was difficult to understand; for, in all the speculations of the ancient astronomers, it was taken for granted that the motion of the heavenly bodies must be supposed to be in circular orbits and with uniform velocity. Of course we

LHOAVTEE

know now that both of these presuppositions were false, and it is a little difficult for us to understand why those notions were held with so great a degree of confidence. But it was supposed that the circle, in its complete symmetry, was the one perfect curve, and that it would be contrary to the eternal fitness of things for the heavenly bodies to move in any other than a circular path, or to move otherwise than with uniform velocity. Erroneous as were these notions, there was a truth underlying them—the truth expressed in Plato's oft-quoted phrase, "God geometrizes"—the truth that the harmony of perfect law pervades the universe, and that all seeming irregularities in nature are due only to the imperfection of our knowledge. The problem to be solved by the Greek astronomers was, then, to account for the apparently irregular movements of the sun, moon, and planets, on the supposition that their real movements were in circular orbits, and with uniform velocity. The solution of the problem was given by Hipparchus in the middle of the second century before Christ; and, with somewhat fuller elaboration, the same theory was given in the "Almagest" of Ptolemy about the middle of the second century after Christ. The title by which Ptolemy's work is known is a curious illustration of a phase of the intellectual history of mankind. Ptolemy's work, which, of course, was written in Greek, bore the title, Ἡ *μεγίστη σύνταξις τῆς ἀστρονομίας*. But, in the middle ages, the original work of Ptolemy was lost, and no manuscript of it was discovered until the fifteenth

century. In the meanwhile it had been translated into Arabic in the Saracen revival of learning, and so came to bear the Arabic name of "Almagest," which is essentially a hybrid combination of an Arabic article with the adjective which forms the first word of the Greek title. To medieval scholars the writings of Ptolemy were known by a Latin translation made from the Arabic.

The theory of Hipparchus and Ptolemy in regard to the movement of the sun around the earth was simply that the earth was not in the center of the sun's orbit, but a little removed from the center. This, of course, would give to the apparent movement of the sun a variable velocity. The sun would seem to move faster in that part of its orbit in which it was nearer to the earth, and more slowly in that part of its orbit in which it was farther from the earth. In the case of the moon, whose path appeared more irregular than that of the sun, it was necessary to make the further supposition that the orbit itself revolves in a retrograde direction, or from east to west, so that the position of the apogee (the point of the orbit most distant from the earth) is continually changing. The apparent retrograde movement exhibited at times by the planets could not be explained in quite so simple a way. It was, however, explained, consistently with the supposition of uniform circular movement, by the supposition that a planet revolves in one circle called the epicycle, whose center in turn revolves in another circle called the deferent.

When the movement of the planets was formulated in this wise, as a revolution in an epicycle, which itself revolves in a deferent, certain coincidences revealed themselves. It was necessary to make Mercury and Venus revolve in their respective deferents, and to make Mars, Jupiter, and Saturn revolve in their respective epicycles, in exactly one year. The fact, then, that the time of revolution of two of the planets in their deferents, and of the other three in their epicycles, was exactly identical with the time of the revolution of the sun in its eccentric orbit, ought, it would now seem, to have suggested the idea that those planets were in some way connected with the sun in their movement; but no such significance seems to have been recognized.

As astronomical observations became more accurate and more numerous, additional irregularities in the apparent movements of the planets forced themselves upon the attention of the astronomers; for we now know that the actual path of the planets, under the influence of the mutual gravitation of the sun and planets, is exceedingly complex. But each new discovery of a seeming irregularity in planetary movements only suggested some additional device in the construction of epicycles; so that the theory became overweighted by its excess of complexity. It was in allusion to the extreme complexity which the theory of epicycles finally developed, that Milton represents his "affable archangel" as intimating to Adam that the Creator had left the construction of the heavens

unrevealed in order that he might find amusement in seeing how men would puzzle themselves with the problems of the universe—

> "How gird the sphere
> With centric and eccentric scribbled o'er,
> Cycle and epicycle, orb in orb."

It was in allusion to the same complexity that Alphonso X. of Castile is said to have remarked that, "if God had consulted him at the creation, the universe should have been on a better and simpler plan."

It will be noticed that the Ptolemaic solution of the problem presented by the apparent movements of the heavenly bodies was purely formal and geometrical. It attempted no explanation of the nature of the force by which the planets were impelled in their movements, and constrained to move in their particular orbits. The aim of the Ptolemaic system was solely to find a supposable combination of circles, in which bodies, moving with uniform velocity, would exhibit the apparent movements of the planets as seen from the earth. The problem, as thus defined, presented by the apparent movements of the planets so far as known to Hipparchus and Ptolemy, was completely solved by the system of epicycles; and, as later refinements of observation detected other and minuter apparent irregularities in the planetary movements, a more elaborate construction on the same principles sufficed for their formulation. The time for a dynamic explanation of the movements of the heavenly bodies was not yet.

The Ptolemaic astronomy held substantially undisputed sway until the middle of the sixteenth century. In 1543 a German priest, Kopernik, better known as Copernicus, since in the fashion of the time he wrote in Latin, published the epoch-making work in which the heliocentric arrangement of the solar system was advocated. The book had been written many years before, but its publication was delayed until the very year of its author's death. It is interesting to note that, though the ancient world was well-nigh unanimous in the belief in the geocentric arrangement of the universe, Copernicus was led to speculate in regard to the possibility of a different arrangement by the fact that a few of the Greek philosophers had held the heliocentric view. According to the Copernican theory, the apparent movement of the whole celestial sphere from east to west is due simply to a rotation of the earth, while the apparent movements of sun, moon, and planets within the celestial sphere are explained by the supposition that the moon revolves around the earth, and that the earth and the other planets revolve around the sun.

In two important respects the new theory, as announced by Copernicus, possessed greater probability than the Ptolemaic. In the first place, the constitution of the solar system which it afforded was more simple. Copernicus was, indeed, still under the dominion of the old notion that the symmetry and order of the universe required that the planets should move in circular orbits and with uniform velocity. He was there-

fore compelled to use the device of epicycles to some extent in order to formulate the apparent irregularities in the planetary movements. He was, nevertheless, able to make a decidedly simpler scheme than the Ptolemaic.

A second great advantage of the Copernican system was that it gave a meaning to the coincidences between the periodic times of the planets and that of the sun. The Ptolemaic system, it will be remembered, made Mercury and Venus revolve in their respective deferents in exactly one year. This coincidence, entirely unmeaning on the Ptolemaic theory, was at once explained by the Copernican theory. According to the Copernican theory, the orbits of Mercury and Venus lie between the earth's orbit and the sun; hence the apparent eastward movement of these planets in company with the sun is due simply to the revolution of the earth itself around the sun. In like manner, the Ptolemaic astronomy had assumed the revolution of Mars, Jupiter, and Saturn in their respective epicycles to be accomplished in one year. As the orbits of these planets, according to the Copernican system, lie outside the orbit of the earth, it is obvious that the main fact of their apparent eastward movement is due to their own revolution around the sun, while the chief apparent irregularity in their movement is due to the motion of the earth around the sun, and must, therefore, necessarily have an annual period. A theory that explains remarkable coincidences in the phenomena to which it relates, has obviously a vast

advantage over a theory that leaves such coincidences unexplained.

Early in the seventeenth century two most important observations were made which greatly strengthened the Copernican astronomy. The telescope was invented in or about the year 1609, and in 1610 Galileo availed himself of the newly invented instrument to make two discoveries of immense theoretical importance. The first was the discovery of the moons of Jupiter. The observation of a group of satellites revolving around that planet was obviously a strong confirmation of the doctrine of Copernicus that the moon accompanies the earth as a satellite in its path around the sun. The other discovery made in the same year afforded even more conclusive proof of the superiority of the Copernican to the Ptolemaic system. Galileo found that Venus reveals to the telescope a series of phases like those of the moon, and that at times the visible illuminated surface of the planet is much more than a semicircle. Since, according to the Ptolemaic astronomy, the orbits of Mercury and Venus were situated between the earth and the orbit of the sun, and their revolution in their respective deferents was accomplished in the same time as the revolution of the sun, those planets must always be nearly in the line joining the earth and the sun, as shown in Fig. 1. It was obvious, therefore, that, if they were opaque bodies visible only by reflected sunlight, the illuminated portion of the disk of the planet, as seen from the earth, could never be as much

as a semicircle. By the Copernican system, on the other hand, the planets revolving around the sun in orbits interior to that of the earth must sometimes be

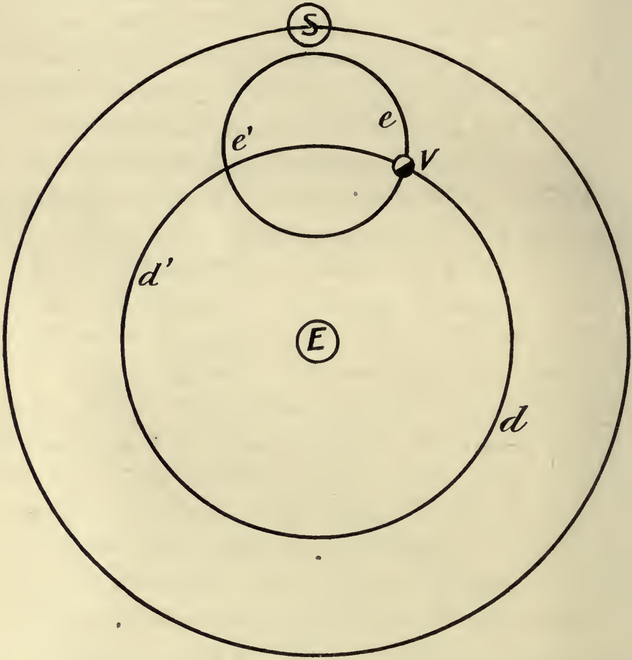

Fig. 1.—Earth, Venus, and Sun, according to the Ptolemaic theory. *E*, earth; *V*, Venus; *S*, sun; *dd'*, deferent; *ee'*, epicycle.

between the earth and the sun, and sometimes beyond the sun, as shown in Fig. 2. The discovery of the gibbous aspect of Venus was, accordingly, a well-nigh conclusive proof of the falsity of the Ptolemaic system.

Copernicus, as we have seen, still clung to the old

notion of circular orbits. The honor of the discovery of the actual form of the planetary orbits belongs to Kepler. In 1609 he formulated the two propositions which have since been known as the first and the second law of planetary movements: namely, first, that

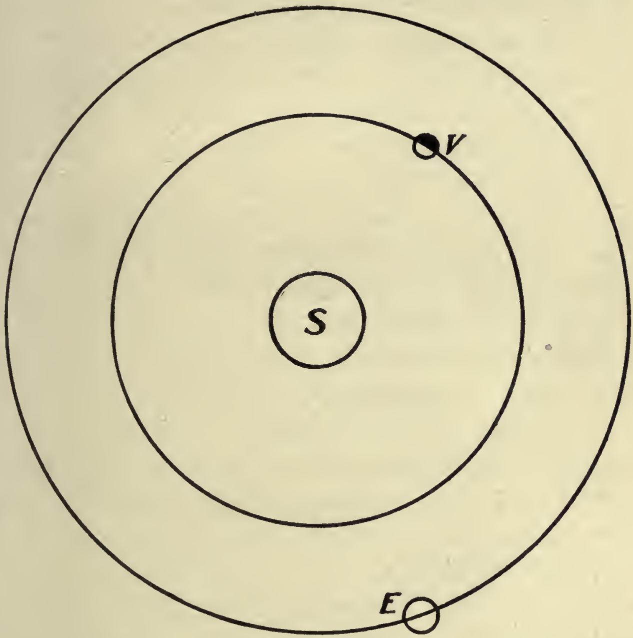

Fig. 2.—Earth, Venus, and Sun, according to the Copernican theory. The aspect of Venus, in the part of its orbit in which it is here shown, would be gibbous.

the orbit of a planet is an ellipse with the sun at one of the foci; second, that the radius vector describes equal areas in equal times. In the discovery of these two laws, respectively, the two venerable fictions of

circular motion and uniform velocity were abandoned. But these laws, as discovered and formulated by Kepler, involved no more of dynamical significance than the conceptions which they displaced. The ellipses of Kepler were as purely formal and geometrical, and as destitute of any dynamical significance, as the eccentrics and epicycles of Hipparchus and Ptolemy. The problem of Kepler was in its essence the same as that of Hipparchus—to imagine a curved path along which a planet might move in accordance with some definitely formulable law, so as to present the apparent movements actually observed. But observational astronomy had made great advances since the time of Hipparchus. The Danish astronomer, Tycho Brahe, in particular, had determined the positions of the planets with much greater accuracy than before; and Kepler had worked with him especially in the study of the planet Mars. With wonderful fertility of conjecture, Kepler tried various combinations of circles, endeavoring in vain to get a satisfactory formulation of the facts then known in regard to the positions of Mars. At length the idea occurred to him to try an ellipse instead of a circle. First he put the sun at the center of his hypothetical ellipse; and, when that failed to reach a satisfactory result, he conceived the idea of putting the sun at the focus. He had reached at last a conjecture which could be verified. His final hypothesis had become a law of nature, and the elliptic form of the planetary orbits has been ever since one of the undisputed truths of science.

Ten years later Kepler announced his third law: namely, that the squares of the periodic times of the planets are proportional to the cubes of their mean distances from the sun.

Thus far astronomical theory had been purely geometrical, but the time had nearly come for astronomy to become a dynamic science. Before this could be done, however, there was need of a preparation to be effected by the progress of related sciences. On the one hand, there was need of a fuller knowledge of the principles of mechanics. Among the physicists of the seventeenth century by whose labors this work was accomplished, an eminent place belongs to Galileo, whose work as a physicist was scarcely second in importance to his work as an astronomer. There was need, too, of a more effective mathematical method for the solution of the extremely complex geometrical problems presented by the movements of the heavenly bodies; and this was furnished in the invention of the differential and integral calculus, achieved simultaneously by Newton and Leibnitz.

With the knowledge of physics which had been accumulated earlier in the century, and with the powerful mathematical apparatus which he himself had invented, Newton was ready to render the closing years of the seventeenth century illustrious by a discovery which has probably been, in its influence upon the course of human thought, the most important single discovery in the history of science. Newton's epoch-making work, the *"Philosophiæ Naturalis Principia*

Mathematica," was published in 1686 and 1687. He showed that, on the supposition that the planets are attracted to the sun by a central force whose intensity varies inversely as the square of the distance, the three laws of Kepler—the elliptical orbits, the description of equal areas by the radius vector in equal times, and the proportion between the squares of the periodic times and the cubes of the mean distances—would follow as necessary consequences. Kepler's laws were no longer simply the ingenious solution of a geometrical problem; they had become an expression of the dynamic constitution of the universe.

But what is that force by which the sun attracts the planets to itself? A conjectural answer to that question, involving a generalization sublime in its scope, suggested itself to the mind of Newton twenty years before the publication of his great work. The most familiar of all physical facts is the tendency of heavy bodies unsupported to fall to the earth. This tendency may be reasonably formulated as a mutual attraction between the earth and those bodies. In Newton's mind, then, arose the question, May not this same force which is thus manifested on the earth be the force which holds the planets in their orbits? But a brilliant conjecture is of little importance in the history of science, unless it can be tested and verified. To that task Newton addressed himself. The moon was known to be distant from the earth about sixty times the earth's radius. It was possible then to estimate what would be the intensity of terrestrial gravitation at the dis-

tance of the moon. Knowing by experiment how far a body near the earth falls in a second or in a minute, a mathematician could calculate how far a body at the distance of the moon ought to fall in a second or in a

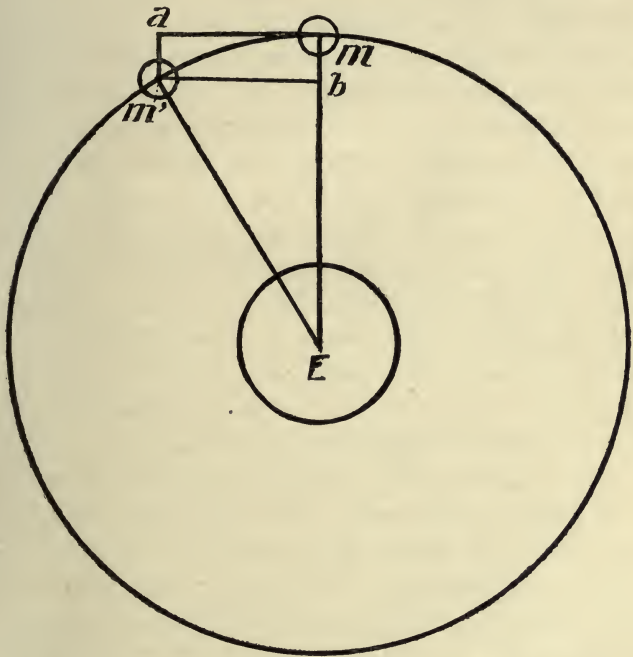

FIG. 3.—The fall of the moon. In passing from *m* to *m'*, the moon falls through the distance *mb* or *am'*.

minute in obedience to the same force. According to the primary laws of motion, a moving body not subject to an external force will continue to move in a straight line and with uniform velocity. The moon,

then, starting from any point in its orbit, should move in the direction of a tangent, unless acted upon by some force drawing it to the earth. The distance, then to which the arc of the orbit has diverged from the tangent, after the lapse of a minute, or any other definite interval of time, will be the distance through which the moon has fallen. Newton accordingly determined that, if the moon was drawn toward the earth by the same force by which heavy bodies fall, and if that force varied according to the law of inverse squares, the moon ought to fall somewhat more than fifteen feet in one minute. The study of the actual positions of the moon showed, however, a fall of only thirteen feet per minute. The discrepancy was too great to pass unnoticed, though the two magnitudes were sufficiently near to equality to suggest the hope that the discrepancy might yet be explained, and the magnificent hypothesis find its verification. Newton laid aside the work, and waited for more light. In due season the light came. Newton's estimate of the length of the earth's radius was based upon a determination of 60 miles for the length of a degree of a great circle of the earth. That estimate is now known to be considerably too small. In 1669 and 1670 Picard made a more accurate measurement of a meridian arc than had before been made, but not until several years later did Newton become aware of the results of that measurement. The age of daily newspapers and weekly scientific journals had not then arrived. Picard's determination made the radius of the earth

about 500 miles longer than Newton had supposed. The distance of the moon, which was known to be about sixty times the earth's radius, and the dimensions of the moon's orbit, were of course increased in the same ratio. Reviewing his calculations in the light of this new knowledge as to the distance of the moon, Newton found the distance between the orbit and its tangent to correspond with the theory. Thus was verified the magnificent conjecture which identified the force that holds the planets in their orbits with the force whose effect is seen in the familiar phenomenon of the fall of heavy bodies to the earth; and thus was developed the far-reaching induction of universal gravitation—a mutual attraction subsisting between all particles and all masses of matter, varying directly as the products of the masses, and inversely as the squares of the distances.*

Newton's discovery of universal gravitation has a twofold significance in the history of science. It was the completion and culmination of that series of astronomical discoveries by which the relative posi-

* It is well, however, at this point to notice that the Newtonian conception of universal gravitation gives no really causal explanation of the movements of the planets, since we know nothing of the nature of the supposed force. (See page 323.) If we strip from the connotation of the word "force" the metaphysical notion of causation, and define force not as the cause of motion or of change of motion, but as the "product of mass into acceleration" (Pearson, *Grammar of Science*, 2d edition, p. 304), the Newtonian conception of planetary movement becomes as purely mathematical as the Keplerian. "Whether, with Kepler, the form of the orbit of a planet and the velocity at each point is defined, or, with Newton, the force at each point, both are really only different methods of describing the facts; and Newton's merit is only the discovery that the description of the motion of the celestial bodies is especially simple if the second differential of their coordinates in respect of time is given." Boltzmann, *On the Methods of Theoretical Physics*, in *London*, *Edinburgh*, *and Dublin Philosophical Magazine*, 5th series, vol. xxxvi, p. 40; cited in Ward, *Naturalism and Agnosticism*, vol. i, p. 81.

tions and movements of the heavenly bodies were determined. It was also the beginning of a series of discoveries by which has been developed the most comprehensive and most important of all the characteristic ideas of science, the idea of the unity of the universe.

The progress of astronomical science led to the recognition of a magnitude of the solar system vastly greater than had been imagined. The sun became, instead of a mere lantern carried around the earth, an orb of colossal size situated at an immense distance from the earth. In later times the discovery of the planets Uranus and Neptune, visible only to the telescope, and far more distant from the sun than any of those known to the ancients, has vastly extended the magnitude of the solar system. But it early became manifest that the dimensions of the solar system are utterly insignificant in comparison with the dimensions of the whole universe. The diameter of the earth's orbit is about 186,000,000 miles. It was a natural suggestion that so extensive a movement of the earth itself should make a perceptible change in the direction of the stars. It was, however, impossible, with the means that were available for observational astronomy in the seventeenth and eighteenth centuries, to prove any change in the apparent direction of a star as viewed, at an interval of six months, from opposite sides of the earth's orbit. If the lines drawn to a star from the extremities of a base line of about 186,000,000 miles are sensibly parallel, that star must be distant indeed. It was not until the close of the first third of the

nineteenth century that astronomical observation had become so refined as to render possible a reliable determination of the value of the angle between the directions of a star as viewed from opposite sides of the earth's orbit—in technical language, the annual parallax of the star. Before the close of that century approximate determinations were made of the distances of a considerable number of the brightest and presumably nearest of the fixed stars. The nearest of these bodies has been shown to be distant from the earth more than 270,000 times the distance of the sun. The great majority of the stars are so immensely distant that the most exquisite refinements of measurement fail to detect any change in their direction.

As the universe grows larger to human thought, the earth grows relatively smaller. It has become a mere speck in the infinite vastness of the universe.

The series of great astronomical discoveries whose history we have sketched was not achieved without theological opposition. Before the epoch of great maritime discoveries, the belief in the sphericity of the earth had been tolerated in the church, but had been regarded with some suspicion as not strictly orthodox. The Copernican doctrine of the revolution of the earth around the sun was regarded in many quarters as flatly contradictory to the Bible, and therefore destructive of Christian faith. For surely it was written, "Thou hast established the earth, and it abideth"*; and, the sun "is as a bridegroom coming out of his chamber,

* Psalm cxix, 90.

and rejoiceth as a strong man to run a race."* And when Newton announced his discovery of universal gravitation, he was charged in some quarters with essential atheism in placing a mathematical formula instead of the power of God in supreme control over the universe.

It lies aside from our purpose to enter into any details of the history of persecution and conflict. The history of the persecution of Galileo is a shameful story; yet our sympathy with "the starry Galileo and his woes" must always be moderated by the fact that his character as a man was far less noble than his character as a scientist. He was conspicuously wanting in those characteristics of tender consideration for the opinions of others and steadfast loyalty to his own convictions which mark the character of the ideal reformer. How far his persecutions were the consequence of his own infelicities of temper we need not specifically inquire. It is worth while to notice in passing that all the astronomers whose names we have had occasion to mention, from Copernicus to Newton, were Christians. Whatever conflict there was, was between Christians and Christians, not between Christians and pagans or atheists.† Copernicus was a devout and faithful parish priest, whose time and thought and care were mainly given to his humble flock. There are few more pathetic pictures in the history of science than that of the aged priest on his deathbed receiving

* Psalm xix, 5.

† Fisher, *Grounds of Theistic and Christian Belief*, revised edition, p. 439.

the first printed copy of the book which was the beginning of a new era in human thought, but which he himself in the last moments of life could not open, and expressing his Christian resignation in the words of Simeon, *"Nunc dimittis servum tuum, domine."* The spirit of Kepler was profoundly religious, and the oft-quoted words which he uttered when the elliptic orbits of the planets shaped themselves before his mental vision, "O God, I think thy thoughts after thee," are worthy to be the motto of devout students in every age. Galileo, though showing by no means the highest moral tone, was a professed believer in Christianity. There were not wanting in high places in the hierarchy of Rome men of enlightened spirit like Cardinal Baronius, the friend of Galileo, who is credited with the epigrammatic statement that the Bible was given to teach us how to go to heaven, not to teach us how the heavens go. Had all ecclesiastics then and in later ages been equally wise and tolerant, many disgraceful chapters in the history of the church might have been left unwritten.

But, while it is not our task to enter into details of the history of conflict and persecution, it is our duty to inquire what was the ultimate effect of these scientific discoveries upon Christian faith. What changes were made in theological beliefs? What did the church learn from these great discoveries?

The revelation of the measureless vastness of the universe certainly gives a new intensity of meaning to the old question of the Psalmist: "When I consider

thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained, what is man that thou art mindful of him, and the son of man that thou visitest him?" And yet, after all, the answer to that question is not materially changed. If we believe in a God of infinite wisdom and infinite love, we can see no reason why he may not be duly thoughtful of the interests of every one of his creatures, though his empire be more vast than men had dreamed, and though the number of its citizens can be reckoned in no human census. We suffered no lack of love and care from our parents, when our younger brothers or sisters were born into our homes. We can trust the love and providence of the Heavenly Father, though the number of his children, in his home of many mansions, be vaster than we had dreamed.

One thing which the church learned from these discoveries was that in the Bible the phenomena of nature are spoken of, not in the language of science, but in terms of purely phenomenal description. The church, indeed, did not learn this lesson as thoroughly as it ought to have learned it, and did not adhere to it consistently in later times. Had it done so, some of the later so-called conflicts of science and religion need never have occurred. Yet it was true, in general, that the church did learn from these astronomical discoveries to recognize that, in regard to the affairs of nature, the Biblical writers spoke the language of common life and not the language of science; and, when that simple truth was recognized, of course there was

no conflict between the Copernican astronomy and the Biblical statements of the sun's daily race and the establishment of the earth forever.

The church might well have learned that the language of the Bible in regard to other subjects than the facts of nature is not technical. The writers of the Bible were no more writing systematic treatises on theology and psychology and ethics, than they were writing systematic treatises on astronomy; and, if the church could only have learned that the language of the Bible was never technical, but always the language of common life, it would have escaped a good deal of pernicious and unsound theology.

The most important fact in connection with these astronomical discoveries, in the sphere of religious thought, was the simple fact that Christianity did survive. Beliefs hallowed by the tradition of ages and so associated with Christian doctrine as to be considered integral parts of Christianity, were shown to be false, and yet Christianity survived. Men's minds adjusted themselves to the new beliefs, and the essential doctrines of Christianity appeared no less reasonable, and its stores of moral inspiration and comfort no less precious; and this history of the survival and unimpaired vitality of Christian faith and Christian life in the change of scientific opinion had its lessons for future ages. In later times, when science said that the universe, instead of being created in six days six thousand years ago, stretched back through time as measureless as the as-

tronomical spaces, or when science said that the universe had reached its present condition, not by a series of isolated creative fiats, but by a continuous evolution, thoughtless men grew merry over the supposed destruction of Christianity, good men grew pale with terror lest the faith which had been the light of the world should go out in darkness, but wise men said that it would be in the eighteenth or the nineteenth century as it was in the sixteenth. Christianity survived with unimpaired vigor when the solid earth on which it had stood was whirled away from beneath its feet. It is not likely to be destroyed by the discoveries of our age or of any age.

II.—The Extension of the Universe in Time*

No one can attentively observe the phenomena presented by almost any part of the earth's surface without recognizing the fact of ceaseless change. In all parts of the world where winters are cold enough for extensive frost work, a pile of rock fragments may be found at the foot of every cliff, often burying the cliff for half or more than half of its height. These fragments have evidently fallen from the summit, from which they have been shivered by the expansion of freezing water in the cracks of the rock. Most rivers are seen to be more or less turbid with the sediment which they are carrying, and thus on slight reflection it becomes obvious that the rivers are transporting the continents seaward. When rivers recede into their ordinary channels after their periodical or occasional floods, the meadow land which has been overflowed is found covered with a film of mud deposited in the inundation; and thus it is seen that rivers have not only a destructive but also a constructive effect. On the shore of the ocean, the waves may be seen in some places to be tearing rocks to pieces and encroaching upon the shore, while in other places they

* For an admirable sketch of the history of geology from ancient times to the early part of the nineteenth century, see Lyell, *Principles of Geology*, ch. ii–iv. See also Geikie, *The Founders of Geology*. For sketches of the more recent progress of geology, see Rice, *Twenty-five Years of Scientific Progress, and Other Essays;* Le Conte, *A Century of Geology*, in *Popular Science Monthly*, vol. lvi. The whole subject is fully treated in von Zittel, *History of Geology and Palæontology*.

are depositing sand in beaches and reefs and spits, and thus extending the area of the land. In many parts of the earth, streams of molten rock are seen from time to time to flow forth from the interior and to solidify at the surface as sheets of crystalline rock. Tremulous movements of the ground are felt from time to time, sometimes so insignificant as to be barely perceptible, sometimes so violent as to destroy whole cities. Not infrequently, after an earthquake, considerable areas are observed to stand permanently at a higher or at a lower level than before. Careful observation shows that along many stretches of coast the land appears to be rising and emerging from the sea, while along other coasts the land appears to be subsiding and the sea encroaching upon it. Thus in various ways the idea is obviously suggested to the thoughtful observer that the earth is undergoing continual change, and that its present condition and aspect are the result of a series of changes which it has been experiencing through the ages of the past. Even in ancient times the attention of thoughtful men was attracted to such evidences of change in the aspect of the earth, and several of the Greek philosophers were led by such considerations to tolerably sound views in regard to many subjects in dynamical geology. In this respect Pythagoras is especially to be commended among the earlier Greek philosophers, and Aristotle among the later ones.

But the fact of change is easily overlooked by the unobservant and the ignorant, because, in general, the

rate of geological change is slow. In most regions there is very little change in the aspect of the earth during a single lifetime. In communities less migratory than ours, it often happened that a man lived to old age in the same house in which he had been born; and to such a man the aspects of nature around his dwelling would be in general substantially the same in his old age as in his childhood. In front of the house, the old man might see the same river running through the same meadow which the child had seen threescore years before, and the same hill might rise behind the house. And so such expressions as "the everlasting hills" became proverbial in common language and in literature.

> "Changeless march the stars above,
>   Changeless morn succeeds to even,
> And the everlasting hills
>   Changeless watch the changeless heaven.
> See the rivers how they run,
>   Changeless, to a changeless sea."

While the general slowness of geological change might easily lead to its being overlooked, there can be no doubt that theological prejudices operated strongly toward the same end. The Old Testament, which Christianity inherited from Judaism, seems to teach that the world was made in six days, by a series of creative fiats, a few thousand years ago. The belief in the supposed authority of that teaching tended to deter men from investigation or question in regard to the history of the world. It is noteworthy that the

same theological prejudice against geological investigation has operated among Jews and Mohammedans, as among Christians; and substantially all of scientific thought since the fall of the Museum of Alexandria belongs to nations that have been at least nominal adherents of these three great religions.

The beginning of modern investigation and discussion of geological subjects was in Italy in the earlier years of the sixteenth century. Of the many who make their pilgrimage to Milan to gaze in reverence upon the most majestic face of Christ which human art has ever painted, comparatively few know that the author of that wondrous painting was not only a painter, but a poet, mathematician, engineer, architect, and, in fact, well-nigh a universal genius. Among his many employments, Leonardo da Vinci was engaged in some of the earlier years of the sixteenth century in the excavation of extensive canals. The rocks through which those excavations were made contained a great abundance of fossil shells, and Leonardo was one of a number of thoughtful men of that time who were sagacious enough to recognize that those fossils were evidence of the former presence of a sea teeming with marine life, where cultivated fields and populous cities had taken its place. But theological prejudices stood in the way of the acceptance of an inference that seems to us now so simple and obvious, and the observations of Leonardo and others were the beginning of a controversy which lasted for about three hundred years. Not till about the beginning of the nineteenth

century were the conclusions of the geologists generally acknowledged.

These three hundred years of energetic and often bitter controversy may be roughly divided into two not very unequal parts. For about a century and a half the question mainly discussed was whether the fossils found in the rocks were really the remains of animals and plants which had once lived on the earth or in the sea. The limits of the present discussion will not permit us to trace that history in detail, nor to set forth at length the particular opinions of those who took part in the discussion. The views of the opposers of geology were in many cases fantastic and absurd. The fossils were explained as mere *lusus naturæ*—sports of nature. Nature must indeed have been a very sportive sort of person to indulge in that sort of recreation so frequently. Others explained the fossils as being due to the influence of the stars, and the stars were so distant that it was not easy to disprove any mysterious and occult potency which might be attributed to them. The fossils, again, were formed by the fermentation of a *materia pinguis* in the earth, though it is needless to say that the existence of such fatty matter was a purely gratuitous hypothesis. In the latter part of the seventeenth century and in most of the eighteenth, the question mainly discussed between the geologists and their opponents was whether, on the assumption that the fossils were really remains of animals and plants, the strata containing them might not have been all deposited in the Noachian Deluge. According to

the narrative of Genesis, after forty days of rain, the waters covered the whole surface of the earth, including the highest mountains, for several months, and all terrestrial animals were destroyed excepting those which had found refuge with Noah in the ark. Of course, the notion seems to us now absurd that accumulations of strata miles in thickness, bearing in the structure of many portions evidences of gradual deposition in tranquil waters, including manifold alternations of different kinds of material, and containing fossils characteristic of each stratum as definitely sorted as in the drawers of a cabinet, could have been deposited in a few months by a tumultuous deluge, even on the assumption that there was a universal deluge. And it seems strange indeed that it should have required more than a century of discussion to dispose of such a theory.

About the beginning of the nineteenth century, we find that the obvious inferences which enlightened thinkers had drawn from the study of the fossiliferous strata three hundred years before, had come to be generally accepted, and the foundations had been laid for all the leading divisions of geological science.

Hutton's "Theory of the Earth," published in the Edinburgh Philosophical Transactions in 1788, and issued in somewhat enlarged form as an independent work in 1795, is recognized as being in an important sense the beginning of the modern development of dynamical geology. A few sentences from this work will clearly indicate its point of view and the spirit in

which geological phenomena were treated: "The ruins of an older world are visible in the present structure of our planet; and the strata which now compose our continents have been once beneath the sea, and were formed out of the waste of pre-existing continents. The same forces are still destroying by chemical decomposition or mechanical violence even the hardest rocks, and transporting materials to the sea, where they are spread out, and form strata analogous to those of more ancient date. Though loosely deposited along the bottom of the ocean, they become afterwards altered and consolidated by volcanic heat, and then heaved up, fractured, and contorted." This general conception of the agencies of dynamical geology is substantially that which has found illustration and confirmation in all the geological study of the nineteenth century. More clearly than any previous writer, Hutton taught the fundamental truth of dynamical geology, that geological effects are to be explained by causes now in operation, and not by unknown hypothetical actions. When a river was seen flowing in the bottom of a deep and rocky gorge, instead of assuming, with the unthinking multitudes, that the gorge had existed unchanged since the creation, or, with some of the theologians of his time, that it was formed by the violent rending of the rocks in the convulsions that the earth experienced when it was cursed for Adam's sin, Hutton showed that the gorge had been formed gradually by the friction of the waters of the stream itself, and particularly by the abrasion of the

sand and pebbles which its rapid current swept onward toward the sea. While Hutton recognized the destructive and constructive action of atmospheric and aqueous agencies, he also recognized, though his knowledge of them was less complete, agencies of a different sort. He held rightly that many of the crystalline rocks had been formed by solidification from a state of fusion like the lavas of volcanoes, and he held to the agency of subterranean forces in the disturbances of the crust of the globe. While the geological theorizing of later time has been largely an expansion and development of the ideas of Hutton, we shall see hereafter that in one important respect his views were seriously erroneous, and have been corrected by larger knowledge and maturer thought.

While Hutton was laying the foundations of dynamical geology, other geologists were making a beginning in other lines of geological investigation. It was in 1790 that William Smith published his "Tabular View of the British Strata," and in 1815 that he published his geological map of England. This was the first example of the detailed stratigraphical survey of a considerable region of country. It may reasonably be regarded as a providential arrangement in the history of science that the first extensive stratigraphical study should have been in England. There is perhaps no other region in the world where the conditions are so favorable for the beginning of that branch of geological study. In a comparatively small area, and in a country whose high state of civilization made roads

and other facilities of travel as good as could be found anywhere, almost the whole series of fossiliferous strata, from the lowest to the highest, is displayed in a fashion remarkably simple. A large part of the series of geological formations extend in roughly parallel bands across the country from northeast to southwest, each dipping southeastward under the next later formation; so that the traveler who journeys from the north of Wales southeastward across the island, traverses in regular succession almost the whole series. Smith's study of the succession of the English formations and the characteristic fossils by which each formation was marked, became a standard with which the rocks of other countries could be compared, in tracing the chronological succession of geological events throughout the world.

William Smith was not a zoologist. He valued fossils simply as labels by which the different formations in the geological series could be identified; and precisely that mode of study of the fossils is perfectly legitimate, and must always be important to the geologist. The characteristic fossils are the marks by which the strata of different ages are to be distinguished. But there is a zoological and botanical, as well as a geological, use of fossils. Fossils are not only marks of the different geological formations; they are records of the history of life, and are therefore of profound significance in biological science. The beginning of the study of fossils from the standpoint of the biologist was made by Georges Cuvier. Before

turning his attention to the study of fossils, Cuvier had made himself eminent as a zoologist and comparative anatomist. He was thoroughly familiar with the structure of both vertebrate and invertebrate animals. In his study of living animals, he had learned to recognize the correlations that subsist between different parts of an organism, whereby, from the knowledge of certain parts, inferences more or less probable may be drawn in regard to the structure of other parts of the body. His knowledge of comparative anatomy enabled him to interpret the significance of more or less fragmentary fossil skeletons. Before his time scarcely any attempt had been made to place the animals and plants whose fossil remains were found in the rocks in any definite relation to the zoological and botanical classifications derived from the study of living organisms. There had been the long discussion as to whether the fossils were really remains of living beings or not; and William Smith and other geologists had shown that fossils could be used as a means of recognition of particular formations in the geological series. But Cuvier showed that the animals and plants represented by fossils could be classified zoologically and botanically and assigned to their place in the systematic series. It was in 1796 that he gave the first illustration of this mode of study of fossils in his research on the huge fossil bones found in Siberia, belonging to the mammoth (*Elephas primigenius*), which, as we now know, ranged over most of northern Asia and Europe and North America. The study of

these fossil bones showed that they were truly the bones of an elephant, yet not the bones of either the Indian or the African species of elephant. The bones accordingly represented an extinct species, yet one so closely related to well-known living species that it could be classed in the same genus. In 1804, he published the first of his classical series of memoirs on the fossils of the Paris Basin. His residence in Paris was perhaps as providential in its influence upon the history of science as William Smith's residence in England, for in the immediate vicinity of Paris were quarries of soft and easily worked rock abounding in the bones of mammals. The application of the new method of study showed these bones to be of extinct species and even of extinct genera, but yet to have such relations to the structures of living mammals that they could be arranged in the same orders. These researches, then, were the foundation of the science of paleontology.

In one important respect the views of all the great geologists of the beginning of the nineteenth century were radically in error. They looked upon the history of the world, not as a continuous development under the operation of uniform laws, but as a discontinuous series of periods of gradual change, alternating with epochs of sudden and catastrophic change. They are often spoken of as the catastrophic school of geologists. Hutton, for instance, clearly understood the processes of degradation of continents by the action of the atmosphere, water, and ice; but his knowledge

of hypogene agencies was so imperfect that he saw no way in which continents could be elevated by the action of any forces known to him to be now in operation. Accordingly he was compelled to believe that from time to time continents were upheaved by some utterly inexplicable catastrophe, after which ensued a long period of relative stability, in which the surface of the continents was slowly degraded by the intelligible processes of weathering and erosion. The paleontologists in like manner accounted for the change in the fauna and flora indicated by the fossil contents of successive series of strata, by the supposition of epochs of universal extermination, each of which was followed by the creation of a new fauna and flora. The two views, of course, naturally fitted together, for it could easily be supposed that the violent convulsions which the physical geologists were compelled to assume, were the occasion of the universal exterminations of animals and plants of which the paleontologists seemed to find evidence.

The contrast between the old and the new views in geology is illustrated in the interpretation of the phenomenon of unconformable strata. In many cases it is observed that a series of strata is tilted up to a more or less steep inclination, and that, upon their edges, which have been planed off to an approximately horizontal surface, there rests a later series of nearly horizontal strata. If the strata in such cases are fossiliferous, it is usually observed that the fauna and flora represented in the upper series of strata differ very

FIG. 4.—Wall of Grand Cañon of the Colorado River. Unconformability is seen at two levels. From Powell's "Exploration of the Colorado River."

widely from those represented in the lower. The interpretation of the facts according to the older geology would be that the interval between the deposition of the two sets of strata was marked by an epoch of convulsion and universal extermination. The modern interpretation would be that, after the deposition of the lower series of strata, there ensued an elevation of the earth's crust in that vicinity, which may have been somewhat rapid or very slow, but was not violent or convulsional, and that the region thus elevated remained above the water level long enough for the rocks to be extensively eroded. Later came a subsidence of the area in question; and, as the district came to be depressed below the water level, it came to be covered by a new series of horizontal strata. Neither the movement of elevation nor the subsequent movement of subsidence had the character attributed to the catastrophes of the older geology; and between the two a period of greater or less length intervened, in which the region was gradually degraded by the agencies of air and water. In like manner, the great change in the species of animals and plants represented in the two series of strata is explained, not by the supposition of an extermination and a new creation, but by the recognition of the long period of unrecorded time in which no strata were deposited in that locality because the region was above the water level. During that time new species may have been formed by processes of evolution, and some species may have migrated into the region in question, and other species may have mi-

grated away from the region, or may have gradually become extinct. The movements of elevation and subsidence, of which the very fact of unconformability is evidence, would naturally open some routes of migration and close other routes. As a result of these processes of evolution and migration continued through an indefinite period of unrecorded time, a complete or nearly complete change in fauna and flora might well be effected without any epoch of universal extermination and new creation. But the history of the downfall of catastrophism and the rise of the new geology will be considered more fully in connection with the discussion of evolution.*

The Antiquity of Man

The most important general result of geological investigation, at the stage which had been reached in the early years of the nineteenth century, was the recognition of the very considerable antiquity of the earth. The present physical condition of the earth was supposed to have been reached as a result of a long series of alternating epochs of catastrophe and gradual change. The existing fauna and flora formed the last of a long series of successive creations. Man belonged to the last of these creations. He was supposed to have appeared in connection with the existing fauna and flora. While the earth, then, was very ancient, man was relatively modern. Nothing indeed was known which contradicted the notion that the antiquity of

* See page 153.

man might be measured by the few thousand years of the traditional chronology.

The accepted doctrine of the very recent advent of man was disturbed by the discovery of human bones and human implements associated with remains of animals now extinct. This discovery clearly contradicted the notion, then universally accepted by geologists, that man had been introduced subsequently to the latest epoch of catastrophe and extermination, and had never, therefore, coexisted with organisms now extinct. The first observations of importance bearing upon the subject in question were made by Schmerling, in the exploration of numerous caves in the vicinity of Liège in Belgium. In the cave breccias and stalagmite floors he found human bones and implements associated with the bones of the cave bear, the cave hyena, the woolly rhinoceros, and the mammoth or woolly elephant, which are now altogether extinct, and with the bones of the reindeer, which is now extinct in Belgium, though surviving in regions farther north. Schmerling's researches were published in 1833 and 1834, but his inference of the actual coexistence of man with these extinct animals was so strongly opposed to the preconceived opinions, not only of laymen and of theologians, but also of geologists, that his memoir received scarcely any consideration. A few years later, in 1847, Boucher de Perthes published an account of his researches in the alluvial gravels on the banks of the River Somme in northern France. These gravels were a deposit of a very different sort from the breccias

and stalagmites of the Belgian caves, but they revealed the same significant fact of the coexistence of human relics with the bones of extinct species of animals. The researches of Boucher de Perthes would probably have been treated, as those of Schmerling had been treated, with undeserved and persistent neglect, had it not been that in 1858 and 1859 the valley of the Somme was visited by three of the most eminent English geologists, Falconer, Prestwich, and Lyell. When these high authorities gave their concordant testimony to the accuracy of the observations and to the soundness of the inferences of Boucher de Perthes, the matter could no longer be ignored. In 1863, the subject was first brought to the attention of the general public by the publication of Lyell's "Geological Evidences of the Antiquity of Man." A condensed statement of the evidence was given on the cover of that book, in the embossed figures of a flint spear-head and a tooth of the mammoth.*

But so contrary to prevalent beliefs was the coexistence of man with these extinct animals that the conclusion was not to be admitted until every possible alternative hypothesis had been thoroughly tested. In the first place, the question was raised, were the supposed implements really of human workmanship? It is noteworthy that even to the present time very few human bones of very great antiquity have been found. The fact is not surprising when we reflect that human

*For an account of these and other finds of relics of ancient man, more concise than that of Lyell, see Lord Avebury (Sir John Lubbock), *Prehistoric Times.*

bodies are seldom left in situations where they can readily be preserved as fossils. Fossils occur chiefly in deposits formed under the waters of river, lake, or sea. In the majority of cases, savage and civilized men alike dispose of their dead by burial in porous soil, where even the bones soon crumble and disappear, or by cremation. Flint implements, on the other hand, are likely to be lost at the margin of streams and lakes, and are well-nigh imperishable even when left on dry land. Moreover, they have been produced in immense numbers. But, when the supposed implements of flint were discovered in localities where no human bones occurred, there was naturally some degree of suspicion as to the truly artificial character of the supposed relics. It is, of course, obvious that purely accidental fractures may occasionally shape a stone into a form much resembling some of the rude implements fashioned by savage art. But, as the finds of such implements increased in number, and as their forms came to be critically studied and compared with those made by savages in various parts of the earth, it came to be universally conceded that they were, beyond reasonable doubt, products of human manufacture.

A second question which was naturally raised was whether these relics were truly contemporaneous with the deposits in which they were found. Unconsolidated deposits like gravel beds are very readily disturbed by various natural events, such as the occasional blowing over of trees whose roots have penetrated to a considerable depth below the surface, or by the work

of man; so that implements and other things which have been dropped on the surface may by accident or by fraudulent design find their way into the interior of the deposit, and may therefore seem to be contemporaneous with it. In the case of the gravels of the Somme, the English geologists already mentioned had the satisfaction of seeing flint implements taken out of the gravel at a considerable depth below the surface, where it appeared to them certain that there had been no disturbance. In the case of implements found beneath the stalagmite crust on the floor of a cave, such a question could scarcely be raised.

A third question which was naturally and rightly raised was whether the bones of the extinct animals were really contemporaneous with the deposits in which they were found. It is sometimes the case, in the disintegration of a fossiliferous rock, that the fossils are transported by the agency of running water just as other fragments of the rock might be, and so come to be included as constituent parts of a newly formed rock. Could it be that the bones of extinct animals had been thus derived from earlier fossiliferous formations? It was not long before that question found its conclusive answer. In a cave at Brixham in England was found associated with flint implements the skeleton of the hind leg of a cave bear, with the bones all in their normal position, including even the patella. Of course it was obvious that the bear's leg was buried in the situation in which it was found, while the bones were still fastened together by their

ligaments. Their derivation from some older fossiliferous stratum was utterly impossible. If possible, a still more conclusive answer to this question was found in the discovery, in the cave of La Madeleine in southern France, of a slab of ivory with a rude picture of the hairy elephant scratched upon it with some flint tool (see Fig. 5). The drawing is rude, but not inartistic, and the animal which is intended to be represented is utterly unmistakable. It is certain that that picture was not reconstructed from scattered bones and teeth. The artist had unquestionably seen the elephant alive.

The effect of investigation was thus to establish beyond reasonable doubt the coexistence of man with the mammoth and other extinct mammals. But what does that fact prove? Does it prove that man commenced to exist earlier than had been supposed, or that some of these extinct animals survived to a later date than had been supposed? A fossil does not, like a coin, bear a definite date inscribed upon it; and our estimate of the antiquity of the human remains and of the bones of extinct mammalia associated with them must be based upon a consideration of a variety of evidence, archæological, paleontological, and geological.

Long before the geological discoveries which started the discussion on the antiquity of man, archæologists had noticed that the prehistoric relics of man and his works in Europe represented three different stages of culture, which were doubtless in a general way consecutive, though the periods represented by these stages

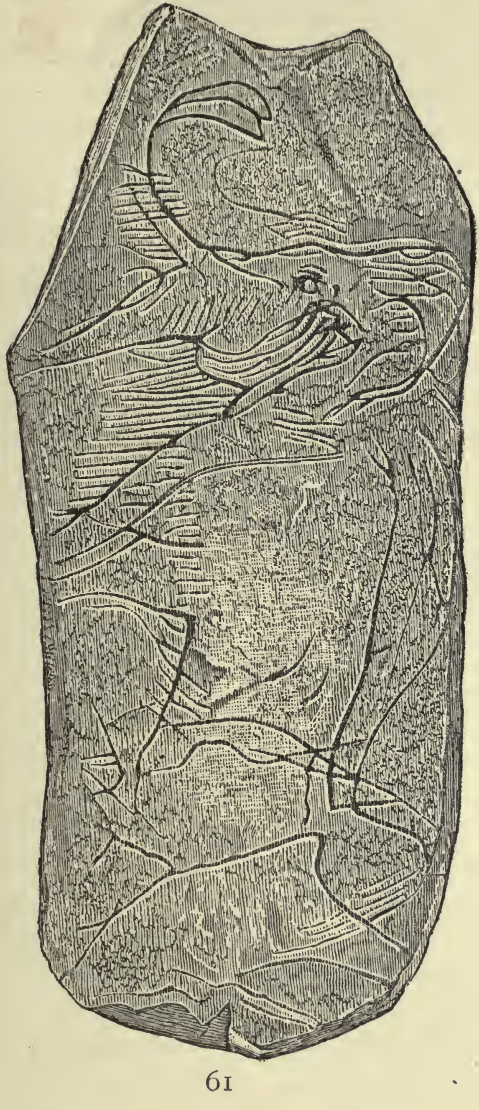

FIG. 5.—Picture of mammoth engraved on ivory by paleolithic man. From Dawkins' "Cave Hunting."

of culture doubtless overlapped to some extent. Among the prehistoric relics of latest date are included implements of iron, showing that they belong to a period subsequent to the invention of processes for the reduction and manufacture of that metal. In another group of prehistoric finds, implements of bronze are present, while iron implements are altogether absent. These belong in general to an earlier date, for the ores of copper and tin, though much less abundant than those of iron, are much more easily recognized, and require much less skill for their reduction. In a still older group of relics, there are implements of stone, and of bone, ivory, and similar materials, but metals are altogether absent. The periods corresponding to these stages of culture were called by archæologists, respectively, the age of iron, the age of bronze, and the age of stone. It is needless to say that these stages of culture correspond to chronological divisions only within the limits of some one particular district of country. Centuries after the European populations had entered upon the iron age, the inhabitants of North America and of Australia were still in the stone age.

When the remains of man associated with the bones of extinct mammals were brought to light, it was obvious, of course, that they belonged to the stone age, but it was equally obvious that they represented a stage of culture vastly lower than that indicated by the later relics of the stone age. It became obvious, in fact, that the stages of culture represented by the ear-

liest and the latest relics of the stone age differed more widely from each other than that of the later stone age differed from that of the age of bronze. It became necessary, then, to divide the stone age into two periods, which were named appropriately the neolithic and the paleolithic—the new stone age and the old

Fig. 6.—Paleolithic implements. From Evans' "Ancient Stone Implements of Great Britain."

stone age. Paleolithic men made implements of stone only by chipping (see Fig. 6). In those localities which probably represent the earliest part of the paleolithic age, the implements are generally of very rude form. In later paleolithic time more skill had been developed, and some of the implements were most artistically shaped, but the process was essentially the same. Neolithic men had found that chisels and

gouges and similar implements could be shaped to a nicer and more uniform edge by grinding than by chipping, and accordingly such implements in neolithic time were ground and polished (see Fig. 7). Time was not as precious in the stone age as in the age of railroads and telegraphs; but time was worth something even to neolithic man, and he did not waste time

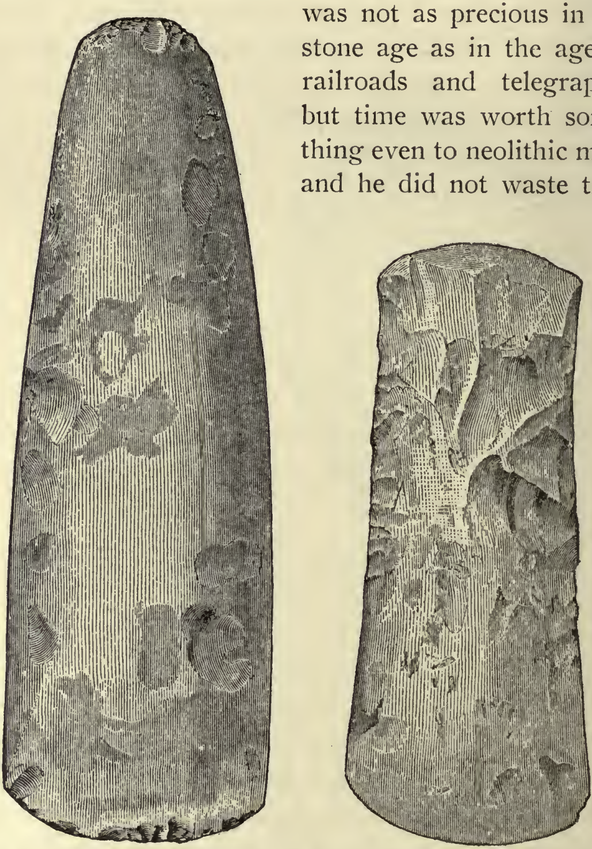

FIG. 7.—Neolithic implements. From Evans' "Ancient Stone Implements of Great Britain."

in grinding arrow-heads and spear-heads and other implements for which a smooth and uniform edge was not required. He retained the art of chipping stone which had been characteristic of paleolithic man, while adding to it the art of grinding stone. Paleolithic man had neither pottery nor textile fabrics; neolithic man had both. Paleolithic man was a hunter and fisher. His only food, aside from the animals which he caught, was afforded by the spontaneous products of the earth. Neolithic man had developed the art of agriculture. Paleolithic man had no domestic animals. In the earliest neolithic finds the bones of the dog are so associated with human remains as to indicate that the dog had already been domesticated. In later neolithic time it appears that horses, cattle, sheep, and goats, and perhaps also pigs, were added to the possessions of man. There is, then, a vast interval in the scale of culture between paleolithic man, with only chipped stone, and destitute of pottery, textiles, agriculture, and domestic animals, on the one hand; and neolithic man, on the other, using both chipped stone and polished stone for his various implements, and possessing pottery, textiles, agriculture, and domestic animals.

If neolithic men in Europe were the improved descendants of paleolithic men, the difference in their stage of culture would doubtless indicate a very considerable lapse of time; but that was probably not the case. It is probable that neolithic man in Europe was an invader, who dispossessed paleolithic man of the territory. The later paleolithic men had developed a

remarkable artistic taste, as is shown by their rude, but often very expressive, pictures of various animals scratched on pieces of bone or ivory.* Neolithic man, though in a far higher stage of general culture, was destitute of this artistic taste. Neolithic man has left us no pictures. If the change from the paleolithic to the neolithic stage represented the advance of a single people in civilization, it would be difficult to account for the loss of the artistic power which had been developed; but, if paleolithic men were exterminated by an invading race, the phenomenon would be perfectly intelligible. On the supposition that neolithic men were invaders who conquered and nearly exterminated the paleolithic race, the difference in their stages of culture gives no clear indication as to the chronology.

The consideration of the remains of animals associated with relics of paleolithic and of neolithic men, respectively, shows that the two races in Europe belonged to distinct periods in the paleontological series. Paleolithic man was associated with numerous mammals now totally extinct, as the cave bear, the cave lion, the cave hyena, the woolly elephant, and the woolly rhinoceros, and with other animals, as the reindeer, that are extinct in the parts of Europe where these relics have been found, though still surviving in regions much farther north. The remains of neolithic man, on the contrary, are found associated almost exclusively with mammals that still survive in the same regions. The only mammals now extinct whose fossil

---

* See Fig. 5, page 61.

remains are ever associated with relics of neolithic man, are the Irish elk, and the wild ox, or urus (*Bos primigenius*). The latter still roamed in great herds in Germany in the time of Julius Cæsar, and its descendants are probably still represented in some breeds of domestic cattle. It may then be fairly said that the Irish elk is the only mammal belonging to the more ancient fauna that survived into neolithic times. Extensive changes in the fauna of a region, by the processes of extinction, evolution, and migration, must be supposed to occupy considerable time; and the paleontological evidence must therefore be considered to indicate a considerable antiquity for paleolithic man.

The history of man may be further correlated with important events in the physical history of the globe. In times geologically recent occurred the remarkable episode called the Glacial period.* There is difference of opinion in regard to the cause of this remarkable phase of geological history, but there is no difference of opinion in regard to the principal effects. The climate, at least of large areas in Europe and in North America, became somewhat colder than it is at present. In mountain regions where now glaciers are found in the higher valleys, those glaciers increased enormously in size, so that they extended far out upon the lowlands bordering the mountains. In the more northern parts of the area in question, glaciers were formed even in regions which, though somewhat elevated, cannot strictly be called mountainous. The mountains of

*See Geikie, *The Great Ice Age;* Geikie, *Prehistoric Europe.*

Scandinavia became the center of a vast ice sheet, which extended southwestward over Great Britain, excepting a little tract in its southwestern corner, southward over the lowlands of Holland and northern Germany, and southeastward over the plains of Russia, blending at its extreme eastern margin with the ice sheet which covered the northern part of the Ural Mountains. In North America, the highlands south of Hudson Bay and between that bay and the St. Lawrence River became the center of an ice sheet still more vast, which covered most of the Dominion of Canada and the northeastern United States, extending at one point even a little south of the Ohio River, and blending in the west with the ice mantle that covered the northern part of the Rocky Mountains. These great areas must have been in substantially the same condition as Greenland and the Antarctic Continent at the present time. At the same time, the Alps formed the center of a smaller ice sheet which extended far over the plains of northern Italy, southern Germany, and eastern France. Local development of glaciers is indicated in the Pyrenees, the Caucasus, and the Himalayas, as well as in the Sierra Nevada and other parts of the western Cordillera in the United States. The formation of continental ice sheets and the increase in the extent of glaciers in mountain regions must have been a gradual process. For a long series of years, the snow-fall of each winter slightly exceeded the summer melting, and so the snow accumulated till, little by little, the vast mantles of ice were

formed. The disappearance of the ice sheets was gradual, like their formation. Year after year the summer melting gained a little upon the winter snow-fall, and the edges of the glaciers receded.

But the more recent investigations of the phenomena of the Glacial period indicate that the history is more complex than is implied in what has been already said. The glaciers advanced and receded, not once, but several times. In the long course of time included in the Glacial period, there were alternations of milder and more severe climate, causing corresponding oscillations in the area of the ice sheets. There is difference of opinion as to the extent of these oscillations, and the amount of territory which was left uncovered from time to time by the recession of the ice; but in regard to the general fact of oscillation in temperature and consequent glaciation there is general agreement.

The earliest remains of paleolithic man in Europe appear to be later than the time of the greatest extension of the glaciers; but, in several localities, relics of man are found covered by glacial formations belonging to some of the later periods of advance of the glaciers. On the geological scale, then, the date of the earliest remains of paleolithic man in Europe must be assigned to some one of the interglacial epochs.

Can we translate, with any reasonable degree of approximation, the paleontological and the geological date of paleolithic man into terms of human chronology? Among the many theories of the cause of gla-

cial climate, one of the most popular in recent years has been that of Croll.* If that theory were the true one, it would give us data for a somewhat definite chronology of recent geological time. Croll's theory of the Glacial period is that it was caused by the conditions which existed in an epoch of great eccentricity of the earth's orbit. It is well known that the eccentricity of the earth's orbit is a variable quantity. At present, the ellipse is of such a form that the difference between the aphelion and the perihelion distance of the sun is about 3,000,000 miles. At present, the eccentricity is diminishing, and the form of the earth's orbit is slowly approaching a circle. It will, however, never become a circle, but after a time will grow more eccentric. At times in the past, the eccentricity has been so great that the difference between the aphelion and the perihelion distance was about 14,000,000 miles. Since the intensity of heat radiation received from the sun varies inversely as the square of the distance, and since the motion of the earth (according to Kepler's second law) is slow in the aphelion and fast in the perihelion portion of its orbit, it is obvious that, with so great eccentricity, if either hemisphere, north or south, as the case might be, had its winter in aphelion, that hemisphere would have a very long and cold winter, and a very short and hot summer. The other hemisphere would have at the same time a short and mild winter and a long and cool summer—a comparatively equable climate throughout the year. In the

* See Croll, *Climate and Time in their Geological Relations.*

opinion of Croll and his followers, the long and cold winter of the hemisphere whose winter was in aphelion would tend to produce glacial conditions in spite of the heat of the short perihelion summer. Owing to other astronomical conditions, the season in which the earth passes its aphelion, changes from winter to spring, summer, and autumn, and to winter again in the course of about 21,000 years. At present, the earth passes its aphelion in the summer of the northern, and the winter of the southern, hemisphere. In about 10,500 years these relations will be exactly reversed. A period of great eccentricity of the earth's orbit, when such a period occurs, is generally of so long duration as to allow several such alternations. In one of these long periods of great eccentricity, the northern and the southern hemisphere would, therefore, experience alternately the conditions of an aphelion winter. This would mean, according to Croll, a glacial epoch for the hemisphere with aphelion winter, and an interglacial epoch for the other hemisphere, the two hemispheres thus alternating in climatic conditions during the period of great eccentricity. The changes in the eccentricity of the earth's orbit can be calculated pretty definitely for long ages past or future. The last period of great eccentricity of the earth's orbit commenced about 200,000 years ago, and closed rather less than 100,000 years ago, so that, if we could accept this ingenious theory, it would give us a tolerably definite date for the Glacial period and for all events which can be correlated therewith.

It is, however, very doubtful whether the conditions of the hemisphere having winter in aphelion in a time of great eccentricity would really tend to produce a glacial epoch. The length of the winter and the shortness of the summer would obviously be favorable to glaciation, since it may well be supposed that during the winter the greater part of the precipitation would be in the form of snow. But the extreme temperatures of summer and winter would not be favorable to glaciation. The amount of snow-fall is not greatly increased by extreme cold in the winter, but extreme heat in the summer must obviously tend to the more rapid melting of the snow. In the case, then, of the hemisphere which has an aphelion winter in a time of high eccentricity, the relative length of the seasons tends to glaciation, but the intensity of heat and cold is adverse to glaciation.* Another objection to the eccentricity theory of the Glacial period is found in the date which it would compel us to assign to that event. The last epoch of great eccentricity came to an end something like 70,000 or 80,000 years ago. But the geological evidence would seem to indicate that the close of the Glacial period could not have been so long ago. The geological traces of glacial work are too fresh to be consistent with so great an antiquity. The moraines which have not been torn to pieces by erosion, the scratched and polished rock surfaces which have not disappeared by weathering, the ponds which have not been drained nor filled—all seem to indicate that the

* *Science*, 1886, vol. viii, pp. 188, 347.

close of the Glacial period must have been within a few thousand years of the present time.

If the eccentricity theory is rejected, the Glacial period must probably be supposed to have been due to terrestrial causes. It seems almost certain that the Glacial period was preceded by an extensive elevation of the continents, particularly of the northern parts of the continents, and it is probable that the climatic change was in part directly and in part indirectly the effect of that elevation. Elevation of land tends directly to depress temperature, for, in ascending from the level of the sea, we find that the temperature falls about one degree Fahrenheit for every three hundred feet. Continental elevation may also change the course of ocean currents, and produce in that way effects upon climate more important than the direct effect of the increased altitude. But probably by far the most important climatic effect of continental elevation, as has been recently shown by Professor Chamberlin, of Chicago University,* is due to the effect of such elevation upon the constitution of the earth's atmosphere. The carbon dioxide of the atmosphere allows solar heat to pass to the surface of the earth with relatively little absorption, but has relatively great power of absorption for the non-luminous rays of great wave-length radiated from the surface of the earth. This gas, accordingly, acts as a blanket to keep the surface of the earth warm. Any increase or decrease in the amount of carbon dioxide would practically,

* *Journal of Geology*, vol. vi, pp. 449, 609; vol. vii, pp. 545, 667, 751.

then, give the earth a thicker or a thinner blanket. The atmosphere is losing and gaining carbon dioxide in many ways. But the source of loss which at present is far more important than any other is the solution of limestones. Whenever limestone is dissolved, the calcium carbonate is converted into calcium bicarbonate, and the carbon dioxide required for this change is drawn from the atmosphere. Of the sources of gain of carbon dioxide to the atmosphere, by far the most important at the present time is found in the marine animals and plants which form calcareous skeletons. These creatures draw the material of their skeletons from the sea water, in which it exists in solution as calcium bicarbonate. Fixing it in their skeletons as calcium carbonate, they restore the excess of carbon dioxide to the ocean, and hence eventually to the atmosphere. The effect of extensive continental elevation upon the atmosphere is both to increase the loss of carbon dioxide by exposing larger areas of land to the solvent action of water, and to diminish the gain of carbon dioxide by converting into land large areas of the shallow seas, in which chiefly live the marine animals which secrete calcareous skeletons. The effect, then, of a continental elevation is to increase the rate of loss, and diminish the rate of gain, of carbon dioxide to the atmosphere.

If the Glacial period is to be explained by terrestrial causes, our only means of reaching a rough estimate of its chronology is by the study of erosion and other geological effects whose date can be correlated with

that event. The gorge of the Niagara River, from the Queenston escarpment back to the Falls, has been considered as affording one of the most satisfactory registers for the estimation of the chronology of the Glacial period. It is probable that the whole length of that gorge has been excavated since the ice sheet retired for the last time from the region of Lake Ontario. Two surveys of the vicinity of the Falls, made respectively in 1842 and 1890, show that in the last half-century the recession at the apex of the Horseshoe Fall has been between four and five feet per year. It seems at first glance to require only the solution of a simple proportion to show the date of the beginning of the excavation. If the river can cut five feet in one year, it can cut seven miles in about seven thousand years. But closer study quickly shows that there are so many elements of uncertainty that the result of such a simple calculation is worthless. The most important disturbing element is that it has been shown to be highly probable that, at two different epochs during the progress of the excavation, the water of the three upper lakes was withdrawn into other channels, so that much of the gorge was excavated by a stream of vastly less volume than the present Niagara.* The drainage basin of Lake Erie affords in fact only about one ninth of the water of the Niagara River. It is probable, therefore, that the time occupied in the excavation was a considerable multiple of seven thousand

* Taylor, *A Short History of the Great Lakes*, pp. 104-108, in Dryer's *Studies in Indiana Geography*, Terre Haute, 1897.

years. It is true in general that the rate of erosion and sedimentation and other geological processes is subject to variation from so many unknown conditions as to render any definite time estimates unattainable. Geology is not, like astronomy, an exact science in its measurement of time. It appears certain, however, that the length of the ice age as a whole, with its alternating glacial and interglacial epochs, was immensely greater than the time that has elapsed since the final retreat of the ice. The amount of erosion accomplished in postglacial time seems utterly insignificant in comparison with that which was accomplished in interglacial times.

While it is impossible to give any definite statement of the lapse of time since that interglacial epoch to which belong the earliest remains of man in Europe, there is probably no doubt in the mind of any geologist that the time must be a considerable multiple of the six thousand years of the Hebrew chronology or of the seven thousand years of the chronology of the Septuagint. Neolithic man apparently entered Europe after the final retirement of the glaciers, and the date of his immigration may have been less than ten thousand years ago. It would be safe to say that at least five figures would be required to express the date of paleolithic man. His first appearance in Europe belongs to an antiquity measured not by thousands of years on the one hand, nor probably by hundreds of thousands on the other, but by tens of thousands of years.

But there is no reason to believe that paleolithic man was indigenous in Europe. As we look back through the period of history into the dim ages of tradition, we seem to see wave after wave of migration coming into Europe from the East. In all probability, paleolithic man, like the races that followed him, immigrated into Europe from the East. Exceedingly important in this connection is the discovery, within a few years, of a human femur and a fragment of a human skull in Java. These remains were, indeed, described by their discoverer as belonging to a creature intermediate between man and ape, which he named *Pithecanthropus erectus*.* They are, however, in all probability human, though more simian in character than any other fossil remains of man. Their location in the East Indian Archipelago, the home of the orang and the gibbon, is exceedingly suggestive to an evolutionist. They may probably claim an antiquity far more remote than that of paleolithic man in Europe.

The question of the antiquity of man was first earnestly discussed on geological grounds, but evidences from various other sources converge towards the belief in an antiquity far beyond the limits of the traditional chronology. On some of the Egyptian monuments belonging to the Eighteenth Dynasty, thirteen centuries before the Christian era, we find paintings of Caucasians and Negroes, exhibiting the contrast in color and in form of face and head as clearly defined as it is at the present time. Perhaps two thousand

* Dubois, *Pithecanthropus erectus*, in *Smithsonian Report*, 1898, p. 445.

years earlier, in monuments referred to the Fifth Dynasty, are figures in bas-relief, which are said to reproduce faithfully the racial characters of the pygmy race of the Akkas described by Schweinfurth

FIG. 8.—Egyptian mural painting, showing contrast between Caucasian and Negro profiles. From Argyll's "Primeval Man."

as living in the country west of the Albert Nyanza.* Strongly contrasting with such a prognathous type are the pure Caucasian outlines of the royal portraits in the early, as in the later, dynasties. The distinct and independent origin of a number of human races is extremely improbable. The whole tendency of scien-

* Keane, *Ethnology*, p. 245.

tific thought would lead us rather to believe that even the most extremely divergent of human races have arisen by variation from a single original stock. But, if races so distinct as the Caucasian and the Negro had acquired their present characters thousands of years ago, the suggestion is obvious that the beginning of that differentiation must have been in remote antiquity.

A similar argument may be drawn from the history of languages. It is indeed true that comparative philology cannot demonstrate the common origin of all human languages. According to William D. Whitney,* the languages of the human race present no such resemblances as would suffice to demonstrate original unity, and no such differences as to demonstrate original diversity. But, if we believe that physically the various races of men have all been derived from a common stock, it appears probable that the same thing is true of their languages. As far back as we can go in the past we find evidence, not only of distinct languages, but even of distinct families of languages. The date of the beginning of differentiation of human speech must be remote indeed.

Evidence in regard to the development of civilization and political institutions points to the same conclusion. The date of the beginning of the Fourth Dynasty of Egyptian kings, the builders of the pyramids of Gizeh, is most conservatively estimated by Meyer as more than twenty-eight centuries before Christ.†

* *Language and the Study of Language*, p. 383.
† Hastings, *Dictionary of the Bible*, art. *Egypt*, by W. E. Crum.

W. M. Flinders Petrie would make the date almost four thousand years before Christ.* The builders of those monuments were not primitive savages, but a people of arts and culture and elaborate political institutions. The civilization which Egypt had attained three or four thousand years before Christ must have been the growth of ages. Within the last few years remains have been brought to light revealing a stage in the history of Egyptian civilization far earlier than that of the pyramid-builders—remains whose date, according to Petrie, is about five thousand years before Christ.† The Egyptians of this predynastic period, though far inferior in culture to the invaders who brought in the civilization of the First Dynasty, lived in brick houses, and fashioned implements of metal as well as of stone. Widely scattered over the plateau of Upper Egypt are the flint implements of paleolithic type, testifying to the existence of an earlier race in far more remote antiquity, when climate and geographical conditions were very different from the present.‡ The Babylonian civilization seems to be traced by recent discoveries to a date even earlier than that of the First Dynasty of Egypt.§ Indeed, the Babylonian civilization is believed by many students to be the source of the Egyptian. There seems to be reliable evidence of a well-established civilization in China not less than two thousand years before Christ. According to the chronology deduced by Archbishop Usher

* *History of Egypt*, vol. i, p. 30.
† *Ibid.*, vol. i, p. 8.
‡ *Ibid.*, vol. i, p. 5.
§ Hastings, *Dictionary of the Bible*, art. *Babylonia*, by F. Hommel.

from the Hebrew Scriptures, the Noachian Deluge occurred 2348 B. C. The pyramids of Gizeh, accordingly, by the most conservative estimate, are hundreds of years older than the date of the Deluge in Usher's chronology. It may be said that the Septuagint text would carry the date of the Deluge seven or eight hundred years further back than the Hebrew. But the difference between the Hebrew chronology and the Septuagint is utterly insignificant in comparison with the antiquity demanded for the human race by the convergent evidence derived from all branches of study relating to the prehistoric past.

Genesis and Geology

We must now consider the effect of the discoveries whose history we have sketched, in regard to the antiquity of the earth and of man, upon the interpretation of the Bible and upon the doctrine of the inspiration and authority of the Bible. And first our attention is demanded by the supposed narratives of the creation in the first two chapters of Genesis, and the bearing of geological science upon their interpretation.

Any one who will read the first two chapters of Genesis in any other than a casual and perfunctory way, can readily recognize that they contain not one, but two, narratives of the Creation. The first of these narratives includes the whole of the first chapter and the first three verses of the second chapter. The second narrative includes the remainder of the second chapter. There is no reasonable doubt that the two

narratives were written at different times and by different persons. There is at present, among those who are competent to have an opinion on the subject, substantial unanimity in the belief that the Book of Genesis is a composite structure, containing fragments of documents of various ages which a later editor collected into the present compilation. The two narratives present characteristic differences of language. One such difference may be mentioned, as showing itself conspicuously even in the English translation. In the first narrative the Deity is constantly called "God"; in the second he is as constantly called "the Lord God."

The comparison of the two narratives reveals important discrepancies, or at least differences, between them. The first narrative makes the work of creation occupy six days; the second speaks of "the day that the Lord God made the earth and the heavens." The first narrative makes man the last work of creation; the second makes the creation of man precede that of plants and animals. The first narrative implies the simultaneous creation of a plurality of human individuals—"male and female created he them;" the second describes the making of a single male individual out of the dust of the ground, and the subsequent making of a single female individual out of a rib taken from the body of the man. The first narrative presents the history of creation as a continuous progress from lower to higher forms of existence, in which each stage is pronounced "good" in its time and or-

der; the second gives us a procedure involving experiment and afterthought—the Creator being represented as saying that it was not good that the solitary man he had made should be alone, then proceeding to make the various members of the brute creation, finding among them no "help meet" for the man, and at last making a woman to supply the desideratum. The first narrative conceives the whole process of creation from a quasi-evolutionary point of view—"Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit"—"Let the waters bring forth abundantly the moving creature that hath life"—"Let the earth bring forth cattle, and creeping thing, and beast of the earth after his kind;" the second gives a procedure in the style of the "carpenter God" of the old natural theology—the Deity being represented as manufacturing animals and man out of the dust of the ground, planting a garden, and extracting a rib from the man for the fabrication of a woman.

Evidently the first task for the interpreter who regards these two narratives as scientifically accurate history of the process of creation is to reconcile them with each other. Until that can be done, it is superfluous to inquire whether both or either of them can be reconciled with the teachings of science in regard to the history of man and his dwelling-place. The natural conclusion for a mind free from any dogmatic prepossessions in regard to the inerrancy of Scripture would be that the two narratives are certainly not scientifically accurate history of the process of crea-

tion. If intended to be such history, one of them at least is more or less erroneous.

Moreover, from a literary point of view, it may be reasonably maintained that the narratives have more the appearance of poetry or allegory than of science or history. The parallelism of structure running through the first narrative, and its division into stanzas each of which concludes with a refrain, give it much more the style of a psalm than that of a scientific treatise. The literary character of the compositions certainly suggests the query, whether the original writer of either narrative intended to give a scientifically accurate history.

Long before the development either of Biblical criticism or of geology, thoughtful men recognized difficulties in the way of any literal understanding of some parts of these narratives. Saint Augustine queried what might be the meaning of those sunless days before the creation of the heavenly luminaries. But it is not within the scope of our present discussion to review in detail the interpretations of the early chapters of Genesis in patristic and medieval time. We are concerned at present only with the history of interpretation since the rise of the science of geology.

But, before proceeding to sketch the history of the interpretations which have been developed under the influence of geological facts and theories, it is necessary to remark that that history has taken a peculiar form in consequence of the fact that the conceptions of geology first became prominent in the world's thought

at about the same time with a particular stage of development of the doctrine of the church with reference to the inspiration and authority of the Scriptures. Had the conceptions of geology entered into the general current of the world's thought either earlier or later than they did, that history (at least as regards the Protestant churches) might have been considerably different.

That God has given a revelation through the medium of inspired men, has been indeed a part of the faith of the Church Universal. "Holy men of God spake as they were moved by the Holy Ghost." The Holy Ghost, according to the Nicene Creed, "spake by the prophets." And, ever since the books of the New Testament were collected and formed into a canon, the Bible has been cherished as the precious record of that revelation. But inspiration is not omniscience. And the belief that the writers of the Bible were under the special influence and guidance of the Divine Spirit is a very different thing from the belief that their opinions were always just, their arguments always conclusive, or their knowledge of facts always accurate. The dogma of inerrancy of Scripture appears in none of the ancient creeds, and forms no part of the Catholic faith. In patristic times, Saint Jerome, the leading Biblical scholar of the early ages of the church, did not hesitate to say that Paul's argument based on the singular number of the word "seed" (Gal., iii, 16) was addressed to the "foolish Galatians," and was adapted to the comprehension of those to whom it was addressed. It does not concern our present purpose to

inquire whether Jerome's judgment in regard to the value of Paul's argument was sound or not. The fact that he felt at liberty to hold and express such a judgment shows how far he was from believing in the inerrancy of Scripture. Such a belief was not held by the early Reformers. The freedom of Luther's treatment of some books of the Bible is well known. The Epistle of James he pronounced *"recht strohern,"* since it seemed to him to conflict with the Pauline doctrine of justification by faith. Calvin and others of the Reformers, though less violent than Luther in their forms of expression, recognized, as explicitly as he, that the spiritual enlightenment of the writers of Scripture was in varying degrees, and did not infallibly preserve them from errors of memory or of opinion.

But the weaker spirits of a later generation were frightened by the work which the Reformation had accomplished. Having cut loose from the authority of the Church of Rome, they found themselves adrift on a sea of speculation, and sought in terror some post to which they could moor themselves. The infallible Church was gone forever; but something infallible must be found to take its place. Hence came the dogma of the inerrant Bible. I do not of course intend to charge the theologians of the post-Reformation period with the conscious dishonesty of manufacturing a dogma to meet a supposed moral need. There is an unconscious logic of hopes and fears which insidiously smuggles its conclusions into the realm of the intellect; and I believe the genesis of the new dogma from the

terrified sense of need of infallible authority was no less real because unconscious.

The Bible, then, was asserted to be absolutely inerrant—its most insignificant details, as well as its most important teachings; its merely incidental allusions, as well as its central and essential doctrines. Every sentence within the covers of the Bible must be assumed to be absolutely "the word of God." The Bible must therefore be recognized as a normative authority for the belief of a Christian, not simply within the sphere of morals and religion, but on every subject which may be incidentally mentioned.

But the post to which the bark of faith was to be moored must be not only firmly grounded, but also stiff and inflexible. To serve the purpose of a normative authority, not only must the Bible be absolutely infallible, but also it must admit of no diversity of interpretation. Hence came the dogma that everything in the Bible must be construed with absolute literality, unless an explicit indication to the contrary is contained in the text itself. No allowance is to be made for the characteristics of the Oriental mind, which are so conspicuous on every page to him who reads the Bible with any literary sense. In spite of its obviously dramatic form, the Book of Job must be considered veritable history, since it is not explicitly stated to be unhistorical. The story of the nobleman who delivered ten pounds to his ten servants is expressly called by the evangelist a parable; but, as the story of the rich man and Lazarus is not so labelled, the latter story must be considered

veritable biography. The eschatological symbols of the Apocalypse—the great white throne, the assembly of the dead for judgment, the opening of the books, the lake of fire and brimstone, the jasper-walled New Jerusalem—are all to be interpreted with wooden literality.

In order to maintain the inerrancy of Scripture, all discrepancies between different narratives of or allusions to the same event must be explained away. This has been done on the principle that omission of particulars is not inconsistent with inerrancy. If, therefore, the particulars given in different narratives are different, the reconciliation must be found in the construction of a narrative which will include all the particulars given anywhere. If Matthew says Jesus healed two blind men as he was leaving Jericho, and Mark says that he healed one blind man as he was leaving Jericho, and Luke says that he healed one blind man as he was entering Jericho, the narratives must be harmonized by the assumption that he healed one blind man on entering and two on leaving the city, the conversations in the two cases being substantially identical—a supposition which, however improbable it may be, is not absolutely impossible, and which is not explicitly contradicted by either narrative. Since no erroneous particular can be anywhere inserted, the general rule of interpretation was developed, that in all cases the account which is fullest in particulars must be considered as the standard, and briefer accounts must be so explained as to harmonize therewith.

These principles applied to the first two chapters of Genesis served to develop a theological theory of the process of creation. Both narratives must be assumed to be absolutely inerrant; both must be interpreted with absolute literality; every particular given in either must be included in the composite narrative. The first narrative is fullest in detail in regard to the lower orders of creatures, the second in regard to man. Hence the first narrative must be the standard for the early stages of the history, the second for the concluding stages. The work must be conceived to have occupied six literal days; and, when the second narrative speaks of "the day that the Lord God made the earth and the heavens," the word day must be taken in a loose and unchronological sense, or else the making of the earth and the heavens must be understood to refer simply to the initial act of creation of matter. The order of events given in the first narrative must be accepted as the true one; and the different order in the second narrative must be considered as due to the fact that that narrative is merely a brief summary, in which chronological succession is ignored, and only results are given. The creation of man must be supposed to have taken place as the closing work of the sixth day, according to the first narrative; but its method must have been that given in detail in the second narrative—the forming of a single male individual out of the dust of the ground, and (after the procession of the animal kingdom before the man, and the failure to find a help meet for him) the deep sleep, the removal of the rib,

and the production of the woman. Thus, by judiciously ignoring or explaining away a few phrases, the two narratives were "harmonized," and a Biblical theory of the process of creation constructed.

Such was the doctrine of Holy Scripture, and such the interpretation of the first two chapters of Genesis, which had been developed in the Protestant churches, at the time when the new science of geology began to make its influence prominently felt in the general current of the world's thinking.

There was, indeed, a short period in which it seemed as if the new science might bring some aid and comfort to believers in the literal truth of the early chapters of Genesis. When, after more than a century of controversy, it came to be generally acknowledged that fossils were actually relics of plants and animals of an earlier age, it was for a time widely maintained that the fossiliferous strata were deposited by the waters of the Noachian Deluge. The marine shells found high up on the Alps were hailed as strong confirmation of the Mosaic narrative of the Flood, by whose waters "all the high hills that were under the whole heaven were covered." It is interesting to find Voltaire suggesting that the marine shells found on the Alps were only the scallop-shells thrown away by pilgrims on their return from the Holy Land.

But the hopes of the theologians to find in the new science support for the orthodox theory of the creation and early history of the world proved illusive. Further study made it obvious that the deposition of the

fossiliferous strata was not to be attributed to the Noachian Deluge. And so the conflict between geology and Genesis commenced, with the demand of the geologists for an indefinite allowance of time, in which the earth could have passed through the manifold series of physical and biological changes of which the strata are the monument.

Of course the first attitude of the interpreters of Genesis was that of simple denial of the conclusions of the geologists. Some invented a variety of more or less absurd theories to account for the origin of the stratified rocks with their fossil contents, such as the hypothesis of a reversal of continent and ocean at the time of the Noachian Deluge, and the consequent appearance on dry land of the deposits formed on the ocean bed in the centuries between the Creation and the Deluge. Others contented themselves with denouncing the geologists as infidels, without taking the trouble to excogitate any hypothesis for the explanation of the phenomena on which the doctrines of the geologists were based. A typical expression of the way in which geologists were regarded by the church in general, in the latter part of the eighteenth century, is found in the words of Cowper,—

> "Some drill and bore
> The solid earth; and, from the strata there,
> Extract a register by which they prove
> That He who made it, and revealed its date
> To Moses, was mistaken in its age."

But the progress of science could not be stopped by

the denials of stolid ignorance or by the perverse ingenuity of pseudo-scientific hypotheses. The time soon came when the belief in a considerable antiquity of the earth was so generally accepted that it was obviously necessary for theologians to accommodate themselves to it. The problem then was to maintain the absolute literal truth of the first two chapters of Genesis, and at the same time concede the indefinite eons demanded by the geologists. And, when the necessity was recognized, nothing was easier. The first narrative begins as follows: "In the beginning God created the heaven and the earth. And the earth was without form and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, 'Let there be light.'" Now inerrancy in a narrative does not imply completeness. Any number of facts may be passed over in silence, provided there is no inaccuracy in the particulars which are asserted. Any amount of history may therefore have had its place between the "beginning" mentioned in the first verse and the chaos described in the second verse. Some exegetes a little more ingenious made the discovery that the second clause in the narrative might be translated, "And the earth *became* without form and void," thereby giving an implication of a more or less extended series of events preceding the reign of chaos. So the theologians said to the geologists, "Put in all the time you want between the first and the second verse of Genesis. Build up your piles of strata by processes of erosion and sedimentation as leisurely

as you choose. Let as many generations of monsters now extinct as the imagination of man's heart can conceive disport themselves through measureless eons. Only allow the history of the extinct creations to terminate, a reign of chaos and darkness and death to supervene, and the present arrangements of the earth, with the present races of living creatures, to be produced in six literal days, six thousand years ago."

Thus the problem was solved without departing a hair's breadth from the literal meaning of any word in the narratives of Genesis. And for the time the geologists were satisfied. All they wanted was time; and this exegesis gave them all the time they wanted. The geologists of the closing years of the eighteenth century and the first third of the nineteenth century were all catastrophists.* They knew no mode of transition from the physical and biological conditions of one geological period to those of another, except by tremendous cataclysms or convulsions of nature, exterminating all living creatures, and leaving the field clear for a new creation. The chaos of the second verse of Genesis was therefore only the last of the catastrophes of geological theory. And there was no reason then known to geologists why that last catastrophe might not have been as recent as the Mosaic chronology required.†

But the truce was of short duration. Catastrophism in geology was dethroned, and uniformitarianism

---

* See page 51.
† See Hitchcock, *The Religion of Geology*, lect. ii.

reigned in its stead. Geological periods were no longer conceived to be separated from each other by chaotic cataclysms. More critical paleontological study showed that seldom, if ever, was the change of fauna and flora complete in passing from one stratum to another. Some species survived, while the majority became extinct. Even in those rare instances in which the change of fossil contents between successive formations seemed to be complete, it began to be believed that the facts proved not a sudden and universal extermination of life, but only an unrecorded interval during which the fauna and flora were more or less gradually changing. It became substantially certain that no universal extermination of life preceded the dawn of the Recent period. Some species which still survive commenced in the Eocene, if not earlier; and, all through the Tertiary and Quaternary, old species were gradually becoming extinct, new species being introduced, and the fauna and flora gradually approximating those of the present time. Early in the latter half of the nineteenth century, the coexistence of relics of man with fossil remains of the mammoth and other species of mammals now extinct came to be accepted as unquestionable. This showed conclusively that there was no chaotic break between the age of man and the ages preceding. A feeble attempt, indeed, was made in some quarters to make the Glacial period do service as the chaos required by the traditional interpretation of Genesis; but the Glacial period utterly fails to fulfill the requirements. It wrought no universal extermination of

life, followed by a new creation. Multitudes of species simply migrated southward, as the ice sheets of Europe and America slowly extended themselves from their centres in the Scandinavian and Laurentian hills, and followed back on the edge of the retreating glaciers, as the climate of those regions gradually ameliorated. And over the greater part of the earth's surface there was nothing which could be called a Glacial period.

The theory of anything corresponding to the chaos of the traditional interpretation of the second verse of Genesis, intervening between the latest of past geological periods and the present, became manifestly untenable. There was, however, a curious modification of the theory, proposed by J. Pye Smith,* which was incapable of refutation. That proposition was to consider the chaos, with its darkness and death, and the creation of a new order of things, as purely local, pertaining only to the immediate vicinity of the Garden of Eden. It would certainly be impossible to prove that there was not some unknown area somewhere, in which, six thousand years ago, there was an interval of darkness and death, followed by a period of six literal days, during which the atmosphere was made once more to admit the sunlight, and some animals and plants were created. But there are theories in regard to which refutation is equally impossible and unnecessary. To save the supposed inerrancy of the first chapter of Genesis, at cost of stripping it of all its dig-

* *The Relation between the Holy Scriptures and Some Parts of Geological Science*, lect. vii, part ii.

nity and significance, is a very poor service to Christian faith. The theory of a local chaos never gained many converts. The common sense of the church seems to have recognized that, if the credit of the Mosaic narrative could be saved only by such a device, it was not worth saving. The theory is, however, interesting as illustrating the tendencies of the prevalent doctrines in regard to the inspiration and the interpretation of Scripture.

With the abandonment of the attempt to interpolate all geological history between the first and the second verse of Genesis, and thus to preserve intact in its literality the story of the creative week, it became necessary to find some new scheme of reconciliation. We have already seen that the spirit of the post-Reformation doctrine of Scripture was adverse to any departure from strictly literal interpretation. But inerrancy must be maintained, if necessary, at cost of sacrifice of literality. If the literal interpretation of a Scripture passage yields a sense which is obviously false, then it must be assumed that some figurative interpretation is the true one. In any case, Scripture must be so interpreted as to convey no erroneous meaning. There came in, accordingly, a class of schemes of reconciliation whose essential characteristic was that the days of the creative week were considered in some sense symbolic or representative of indefinite periods of time.

It is a curious illustration of the tenacity with which theologians clung to a literal interpretation, that some of the earliest writers who regarded the creative week

as a period of indefinite length, attempted nevertheless to hold fast, at least in form, the notion of literal days. Certain writers, for instance, suggested that, in the early periods of the earth's history, the rotation of the earth on its axis may have been inconceivably slow, so that a literal day may have been an immensely long period of time. It is needless to say that astronomy gives to any such notion an unqualified contradiction. Others suggested that Moses does indeed give the history of six literal days; but that those days, instead of being consecutive, were separated by immense intervals of time, so as to be representative of successive periods in the history of creation. This seems only a juggle of words; but it is interesting as illustrating how reluctantly the literal interpretation was abandoned.*

But, however reluctantly, it was at last abandoned; and the scheme of symbolic days, in some form or other, came into general acceptance. It will be noticed that the word "day" came to be regarded as meaning an indefinitely long period of time, not because that interpretation was considered a natural one, but because it seemed to be necessary in order to save the historic truth of the narrative. It had become substantially certain that the universe was not made in six literal days; but it might be considered to have been made in six indefinite periods. Therefore, an inerrant writer could not have intended to say that the universe

---

* References to the authors of these transitional opinions are given in Hitchcock, *Elementary Geology*, 30th edition, 1859, p. 348.

was made in six literal days, but might have intended to say that it was made in six indefinite periods. The interpretation was necessitated by the prevalent theory of inspiration. Whether the interpretation can be considered a legitimate one, is a question which only Hebrew scholars can decide. The corresponding Hebrew word, like the word "day" in English, is undoubtedly often used indefinitely for the time at which something occurs, without regard to duration, and may also be used in poetry in a variety of altogether figurative senses; but whether, in a composition of historical or scientific character, it can be understood to mean an eon, is a different question. Whether the interpretation itself be legitimate or not, the critic unbiased by dogmatic prepossessions must consider the process by which it was reached essentially illegitimate.

It is certain, nevertheless, that the scheme of symbolic days gives a higher and more dignified character to the Biblical narrative than the earlier scheme of interpolating all geological time between the first and the second verse of Genesis. It makes the theme of the first chapter of Genesis the creation of the heaven and the earth—not a supposed incident in the conclusion of the process. In this it is certainly more true to the spirit of the passage. Whether the passage is history or poetry, scientifically exact or more or less erroneous, divine revelation or human imagination, there is no reasonable doubt that the theme it intends to treat is the creation of the heaven and the earth. The new scheme has also an attractive feature in the meaning

which it gives to the seventh day—the Divine Sabbath. If the six days were periods of indefinite length, the seventh day may be considered to extend from the creation of man to the consummation of earth's history. The work of creation having culminated, and in an important sense terminated, in the introduction of man, the characteristic activity of the Deity in terrestrial affairs is thenceforward a moral and religious work—the training of his human children for spiritual fellowship with himself. In this view, the Divine Sabbath becomes a beautiful type of the day of Christian worship—not the idle repose of a tired laborer, but earnest activity, inspired by holiest feeling and directed to the noblest purpose.

The theory of symbolic days has been developed in a variety of forms. On the general assumption that the days of Genesis represent successive periods in the process of creation, interpreters have differed widely as to the question what natural events are referred to in the somewhat vague language descriptive of the work of each day. Two of these schemes may be taken as specimens; and the comparison of the two will be instructive.

One of the earliest, and perhaps the best, of these schemes was proposed a generation ago by Hugh Miller.* His general conception was that the work of creation was presented to the mind of the seer in a series of visions—ideal landscapes, so to speak—representing successive stages in the history of the

* *The Testimony of the Rocks*, lects. iii, iv.

globe. As the material for his narrative was given in the form of visions, his description is to be considered purely visual—phenomenal. He sketches in picturesque language the most conspicuous features of the pictures presented to his imagination, making no attempt at scientific interpretation of them. As the whole Biblical conception of the universe is geocentric, the "Mosaic vision of creation" forms no exception. The heavenly bodies are considered simply as incidents or adornments of the earth. The work of the first day—the creation of light—represents accordingly the stage of the earth's development in which the atmosphere first became sufficiently diaphanous to allow light from the sun to penetrate to the surface. The precipitation of condensing vapors to form the primeval ocean is supposed to have proceeded so far as to give the atmosphere some degree of translucency some time in the course of the Archæan age. The second day's work—the creation of the firmament—represents a stage in the condensation of vapors when the lower strata of the atmosphere had become tolerably clear, while a continuous ocean of cloud filled the upper regions, rendering sun, moon, and stars still invisible, though the amount of diffused light had increased. This condition is supposed to have been reached early in the Paleozoic eon. The works of the third day—separation of land from water, and creation of plants—find their obvious explanation in the broad continental areas and luxuriant forest vegetation of the Carboniferous. The fourth day's work—creation of sun,

moon, and stars—represents the period when the condensation of vapors and clarification of the atmosphere had proceeded so far that the sun, moon, and stars became visible from the surface of the earth. This stage Miller supposes to have been reached in the latter part of the Carboniferous or in Triassic time. The fifth day's work—creation of sea monsters—is naturally referred to the culmination of reptilian life in the later Mesozoic. The works of the sixth day—creation of beasts and of man—correspond well with the culmination of mammalian life in the Cenozoic, and the appearance of man in the Quaternary.

A very different scheme has been proposed by Professors Dana* and Guyot;† and the deservedly high respect in which these great Christian scholars have been held has secured for their scheme very general acceptance. They give to the first chapter of Genesis a more strictly scientific character than is attributed to it by Miller. The description is supposed to be not purely visual or phenomenal, but somewhat philosophical. The ideas were communicated to the mind of the seer, not by vision, but by some other mode of revelation. The significance of the first two days is not terrestrial, but cosmical. The work of the first day is the beginning of molecular activity in matter. Since all forms of physical energy are correlated, the dawning of light would be the sign that those transformations

---

* *Manual of Geology*, 3d edition, p. 845; *The Genesis of the Heavens and the Earth; Bibliotheca Sacra*, vol. xlii, p. 201; *Old and New Testament Student*, vol. xi, pp. 12, 84.

† *Creation; or, the Biblical Cosmogony in the Light of Modern Science.*

of energy which constitute the history of nature had commenced. The second day's work—the dividing of the "waters which were under the firmament from the waters which were above the firmament," or, in more technical language, the dividing of the fluids from the fluids—is interpreted as referring to the separation of the molten mass of the earth from those of the sun and the other planets—the individualization of the earth, in accordance with the nebular theory. The works of the third day refer to the beginning of differentiation between continent and ocean, and the appearance of the simplest and humblest forms of vegetation. The former of these events certainly occurred in the Archæan, and the latter probably before the beginning of the Cambrian. The fourth day's work is considered by Dana and Guyot, as by Miller, to represent the stage of condensation of atmospheric vapors which rendered the heavenly bodies visible from the surface of the earth. According to these writers, however, that stage was reached about the beginning of Paleozoic time, rather than at the much later date assigned by Miller. The fifth day's work is interpreted as referring to the gradual unfolding of the types of structure of the animal kingdom (exclusive of the mammalia), through Paleozoic and Mesozoic time. The chronological reference of the sixth day is essentially the same as in Miller's scheme.

The comparison of these two schemes with each other and with the facts of paleontology may be facilitated by a tabular statement. In the table on page 103,

Table of Geological Ages

Eons.	Eras.	Changes in Fauna and Flora.	Miller.	Dana.
Cenozoic	Quaternary	Man begins.	VI	VI
	Tertiary	Placental mammals begin.		
	Cretaceous	Higher flowering plants begin (angiosperms).		
Mesozoic	Jurassic	Birds begin. Reptiles culminate. Gymnosperms culminate.	V	
	Triassic	Mammals begin (non-placental). Reptiles become much more abundant. Amphibians culminate.	IV	
	Carboniferous	Reptiles begin. Amphibians become much more abundant. Insects become much more abundant. Pteridophytes culminate.	III	V
	Devonian	Amphibians begin. Fishes become much more abundant. Flowering plants begin (gymnosperms).		
Paleozoic	Silurian	Fishes become more abundant.		
	Ordovician	Vertebrates begin (fishes). Land animals begin (insects). Land plants begin (pteridophytes).	II	IV
	Cambrian	Marine invertebrates varied and abundant. Seaweeds.		
Archæan		Evidences of life scanty and dubious.	I	III

the first column gives the four great eons into which geological time is divided, and the second column the eras into which those eons are subdivided. The third column indicates the most important changes in fauna and flora by which each era was signalized, as shown by fossils. The fourth column shows the portions of geological time assigned by Miller to each of the Mosaic days. The fifth column shows the portions of geological time assigned by Dana to four of those days. It will be recognized that the table is arranged in the order of superposition of the geological strata, and must accordingly be read from bottom to top in order to show the course of the earth's history.

The very fact of so wide a discrepancy between these interpretations of a passage which students of nature and of the Bible, so reverent and so learned, have assumed to be a divine revelation of scientific facts, certainly suggests the doubt whether there is in the passage any revelation of scientific facts at all. A divine revelation of a stage in the history of creation is certainly of very little value, if couched in terms so darkly enigmatical that one cannot tell whether they refer to a state of incipient translucency in the earth's atmosphere, or to the beginning of molecular activity in the cosmos; to the formation of a stratum of cloud above the clearing lower strata of the atmosphere, or to the individualization of a molten orb from a condensing nebula. The propounding of mere riddles seems more in keeping with the spirit of pagan than with that of Christian oracles.

It seems on general principles improbable that a revelation of scientific facts and theories should be given. Everywhere else in the Bible, nature is referred to only in the most purely phenomenal way. The aspects of the physical universe are alluded to as they appear to the uneducated senses of man in an unscientific age. The Biblical writers show in general no indication of any knowledge of nature superior to that possessed by other men of their time. Some of them were acute observers of nature in an esthetic fashion—many of the Psalms breathing the spirit of the true nature-poet; but any language implying attempt at scientific explanation of natural phenomena is apt to reveal a totally erroneous conception. It is, then, exceedingly improbable that, in the isolated case of the first two chapters of Genesis, a somewhat detailed sketch of the history of the earth should have been supernaturally revealed. This objection lies with even greater force against the theory of Dana and Guyot than against that of Miller. We might perhaps conceive of a series of visions, exhibiting in pictorial fashion some stages of the earth's history, being presented to the mind of an inspired seer; but it would tax our credulity more severely to believe that there were given enigmatical intimations of the nebular theory and of the doctrine of conservation of energy.

Such a revelation could serve only one conceivable purpose. As the enigmas, unintelligible when first spoken or written, found their interpretation in the discovery of the facts to which they referred, they might

furnish material for a chapter on the evidences of revelation. Not long ago the Bible was supposed to be full of material of an analogous kind. The prophetic passages, both of the Old and the New Testament, were supposed to afford detailed predictions of historical events destined to occur centuries or millenniums subsequent to the date of the prophecy—predictions absolutely meaningless and useless to the people to whom they were written or spoken, but destined to be interpreted by the gradual evolution of history, and so to furnish the material for a perpetually lengthening chapter of Christian evidences. A radical change has come over our conception of the function of prophecy. With more critical determination of the date of some prophecies and the meaning of others, with a fuller recognition of the truth that most of the prophetic utterances having the form of prediction were simply threats or promises conditioned on the conduct of the persons addressed, with the frank acknowledgment that some predictions have failed of exact fulfilment, we have come to regard as the main function of prophecy, not the construction of a map of all future history with symbols and names in cipher, but the presentation of warnings, consolations, and moral exhortations, to reform or confirm the religious faith and life of the people addressed.* It is not likely that the Bible contains prophetic riddles of science, any more than of history.

It can hardly be claimed that any scientific man

* It is not intended to deny that there are some prophecies which look far down the ages; notably, the growing burden of Messianic prophecy, which runs all through the Old Testament.

would, for any scientific purpose, divide the earth's history (whether beginning with the commencement of molecular activity in matter, or with the individualization of the earth) into six co-ordinate periods corresponding with the creative days of Genesis. All that the advocates of either of the schemes we have considered (or of any other form of the theory of days representative of long periods) could possibly claim, is that the earth's history can be arbitrarily divided into six periods, characterized respectively, more or less appropriately, by some one event (or two) whose order of succession will not contradict the order in Genesis. Critically examined, neither of the schemes which we have considered will be found to meet this condition.

The enumeration of the animals which appeared respectively on the fifth and on the sixth day certainly presents difficulties on either scheme of interpretation. It is almost certain that mammals appeared before birds in geological history, while in the order of Genesis birds are assigned to the fifth day, and mammals to the sixth. It may, indeed, be replied that birds probably did precede the typical placental mammals, and that there is no serious error in ignoring the insignificant monotremes and marsupials of early Mesozoic time. It may be further alleged that birds are mentioned in the enumeration of the works of the fifth day, simply as completing the inventory of non-mammalian life, which is collectively contrasted with mammalian life; it being undoubtedly true that non-mam-

malian life in general preceded mammalian life. A somewhat more serious difficulty is found in the word translated "creeping thing" in the enumeration of the works of the sixth day. The word is indefinite in its signification, but it certainly cannot be understood as referring exclusively to the smaller mammals, though these may be supposed to be included. The word includes the terrestrial reptiles and an indefinite variety of terrestrial invertebrates. It is needless to say that most of the groups of animals included in this heterogeneous assemblage antedated considerably in their origin any period of geological time which any form of the theory of symbolic days has appropriated to the sixth day. It may be answered that reptiles (as represented by the larger and the more conspicuous members of the class) are included among the dragons, or sea monsters, of the fifth day (the word "whales" in the authorized version being inadequate, if not altogether incorrect, as a translation); and that the smaller and more insignificant reptiles, amphibians, and invertebrates are ignored in an enumeration which makes no attempt at exhaustive completeness. But the answer seems not altogether satisfactory.

A more fatal difficulty, however, is encountered by both schemes in attempting to give a consistent interpretation of the portion of the narrative included in the third, fourth, and fifth days. Miller cannot put the third day earlier than the Carboniferous era, since no luxuriant and conspicuous forest vegetation characterized the earlier eras. He is, therefore, obliged to

maintain that not until after the Carboniferous did the earth's atmosphere become sufficiently clear for the heavenly bodies to become visible from the earth's surface. This is almost certainly false. The trilobites of the earliest Cambrian had elaborate compound eyes, like their successors, the crustacea of the present day, indicating that they probably lived in good daylight. And it is immensely improbable that the vegetation of the Carboniferous—a vegetation which included flowering, as well as flowerless, plants—was developed without a gleam of direct sunlight.

Dana and Guyot escape from this difficulty only to meet another even more fatal. Dana puts the clearing up of the atmosphere which characterizes the fourth day at the very beginning of the Paleozoic. The closing work of the third day—the creation of plants—is understood to signify the absolute beginning of vegetable life—the introduction of the very simplest and lowest unicellular organisms,—which probably took place in pre-Cambrian time. The beginning of the history of animals was certainly substantially simultaneous with that of plants. The lowest organisms do not exhibit the typical characters of either animals or plants. From that common starting-point of undifferentiated unicellularity the stream of evolution has flowed in two divergent directions. The lowest animals must therefore have appeared simultaneously with the lowest plants. So far as can be inferred from fossils, the animal kingdom was expanded to something like its present range of development earlier than the

vegetable. Vertebrates appear earlier than phanerogams, and birds and mammals before angiosperms. But the first chapter of Genesis puts the creation of plants on the third day, and that of the lower orders of animal life on the fifth, a period of indefinite length being interpolated between them. Dana and Guyot seek to escape this difficulty by interpreting the creation of plants as referring to the absolute beginning of vegetation, and interpreting the creation of animals as referring to the expansion of animal life into varied types. This is obviously illegitimate. Parallel symbols must have parallel interpretations. The creation of plants and of animals respectively may mean absolute beginning, or it may mean full development; but, whichever it means, it means the same thing in the two cases. On neither interpretation can the order in geology and that in Genesis be made to correspond.

There is another, though somewhat less glaring, inconsistency of interpretation in the theory of Dana and Guyot. After explaining the work of the first day, in a manner so sublimely philosophical, as the beginning of molecular activity in matter, it is rather incongruous to interpret the fourth day's work in a sense so humbly visual and phenomenal as the breaking up of the clouds in the earth's atmosphere. In this respect Miller is more consistent.

There are, indeed, other variations of the theory of days symbolic of indefinite periods, but it seems unnecessary to examine them in detail. The two schemes

which have been examined are sufficient to serve as representatives of the class. None of the others have been expounded and defended with greater resources of knowledge and ability. None that I have examined seem more successful in evading the difficulties which beset the attempt to reconcile the order in Genesis with the order in geology.

The conclusion which seems forced upon us is that no reconciliation between the geological record and that of Genesis is possible. The order of events in the first chapter of Genesis is not the order of events in geology. The order of events in Genesis is one which would naturally suggest itself to an unscientific but somewhat philosophical imagination. The inorganic arrangements of the earth precede for the most part the introduction of its organic inhabitants. Plants precede the animals that feed upon them, and the lower animals precede the higher. With the fondness for parallelism so characteristic of the Hebrew mind, each triad of days begins with a furnishing or an adjustment of the illumination of the scene; and each triad ends with a double work, of which the first part is the culmination of the closing era, and the second part a prophecy of the succeeding era. Or, according to another conception of the parallelism, the first triad gives us the different elemental realms, and the second triad the inhabitants of those realms. Thus the first day gives us the realm of cosmic light, and the fourth day the luminaries which may be poetically conceived as the inhabitants of that realm. The second day reveals

the realms of ocean and air, and the fifth day peoples those elements with fish and fowl. The third day produces the terrestrial realm with its adornment of vegetation, and the sixth day crowns the creation with terrestrial animal life. It is a profoundly thoughtful conception of the cosmos; but it is not astronomy, nor geology, nor biology.

If the order of events in the first chapter of Genesis cannot be reconciled with our present knowledge of geology, it is needless to say that the mode of creation of man detailed in the second chapter cannot be reconciled with our present ideas in biology. Believers in evolution certainly cannot believe that the first man was molded out of the dust of the ground, nor that the first woman was made out of one of the man's ribs.

And a reconciliation between Genesis and modern science is as unnecessary as it is impossible. The attempts at reconciliation have been necessitated solely by the post-Reformation dogma of the inerrancy of Scripture—a dogma which has formed no part of the faith of the Church Universal, which has been repudiated by most of the greatest theologians of ancient and of modern times, and which is responsible for an endless amount of perverse ingenuity and sophistication in the interpretation of both the Old and the New Testament. Let us fairly recognize that inspiration does not mean omniscience, and that errors in detail on the part of the Biblical writers, especially on subjects outside the sphere of morals and religion, do not invalidate the claims of Christianity as a revela-

tion. We shall then be freed from any anxiety as to reconciliation between the opening chapters of Genesis and modern science. In a spirit of purely literary and historical criticism, we can then consider what the original writers of the two narratives in Genesis, and what the compiler who put them into the Pentateuch, probably believed and intended to teach—whether the first narrative was intended to be history or poetry; whether the days were intended to have any chronological signification or not; whether the order of events was intended to be an order of time, or only an order of thought; whether the second narrative was conscious allegory, or myth erroneously believed by the writer or the compiler to be history.

The Hebrew traditions of creation present points of parallelism to the Babylonian mythology, and much of the material of those traditions doubtless belongs to the common heritage of the Semitic peoples. They are no more true scientifically in their Hebrew form than in their other forms. That which is characteristic of the Biblical form of these traditions, and that wherein we recognize the divine inspiration of the Hebrew seers, is the pure monotheistic theology and the lofty moral tone which have gained for these ancient documents the reverence of the ages.

Relieved from the supposed necessity of finding in the Mosaic narratives a prophetic anticipation of modern geological science, we shall be prepared more clearly to recognize their moral teaching. We shall find that each of the two narratives conveys its charac-

teristic lesson. The first narrative is a majestic psalm of praise to God as the Creator of the universe. In order to emphasize the antithesis between the monotheism of the Hebrews and the universal polytheism around them, the particular objects of nature which were worshipped by pagan nations are expressly enumerated as the creatures of God. He is the God above all gods. The arrangement in seven sections or days has obvious reference to the institution of the Sabbath. Through the allegorical or mythical form of the second narrative, we see the great truth set forth that God is the providential ruler and guide of his children, the author of the family relation and of social institutions, the inspirer of art and science and civilization. With the moral teaching of the psalm in the first chapter and the allegory in the second, science has no conflict and requires no reconciliation.

Something should be said at this point in regard to the bearing of the geological and other evidences of the antiquity of man upon the Biblical chronology. The Biblical chronology from Adam to Abraham is based upon two genealogical tables contained respectively in the fifth and the eleventh chapter of Genesis. The former table gives the genealogy from Adam to Noah, the latter the genealogy from Noah to Abraham. The chronological data in both of these tables are of the same sort. Each of the persons mentioned is said to have lived a certain number of years and to have begotten a son. On the supposition that the numbers given are reliable, the sum of the series of numbers

representing the age of each patriarch at the time of the birth of the son named in the table will give us the length of time covered by the series of generations in question. It is from data of this sort that Archbishop Usher deduced the traditionally received date of the Creation of the world, 4004 B. C. The numbers given in the Septuagint version differ considerably from those of the Hebrew, so that, if the computation is based upon the Septuagint, the date of the creation is about 1,400 years earlier. But, of course, the difference of 1,400 years between the Hebrew and the Septuagint chronology is of no importance to geologists. The antiquity of man, according to the teachings of geology and the other sciences which bear upon man's early history, requires not the addition of a few hundred years to the traditional date, but the multiplication of the traditional period by a considerable factor. The Septuagint chronology is no more reconcilable with science than the Hebrew chronology.

The only aspect in which the difference between the numbers of the Hebrew and those of the Septuagint is of any importance, is in the indication it affords of the extensive corruption of the tradition or of the text. This indication is confirmed by the fact that in the Samaritan Pentateuch some of the numbers differ from both the Hebrew and the Septuagint. The fact that the texts differ so widely in their numerical statements makes it altogether probable that accidental or intentional alterations of the numbers in question have been so numerous that it is impossible for us to determine

what the original numbers were. That of itself indicates the unreliability of the traditional chronology.

A fact which indicates probable error in these genealogical tables is the enormous longevity attributed to many of the persons. Several of them are said to have lived more than nine hundred years, and one of them, Methuselah, to have attained the age of 969 years. But, according to the teachings of biological science, a somewhat definite period of life is about as characteristic of each species of living creature as a somewhat definite limit of size. A man nine hundred years old would be as much of a monstrosity as a man whose stature was fifty feet. The former is about as incredible as the latter. Some critics have supposed that these immense numbers were originally intended to represent the length of the reign of some dynasty, or the period of dominance of some family or tribe; and that, in the corruption of the original tradition, the period covered by a succession of related lives came to be mistaken for the lifetime of an individual.

Whatever may have been the original form and the original meaning of these numerical statements, it appears substantially certain that, as they stand at present, they are utterly unreliable, and the chronology which is based upon them is absolutely worthless. This, of course, is fatal to the dogma of scriptural inerrancy; and I believe the geological discoveries which have established the great antiquity of man have been exceedingly useful to the church, in the very fact that they have revealed a contradiction between the conclu-

sions of science and the text of Scripture so trenchant, and apparently so incapable of being explained away by any device of exegesis, as to expose most clearly the falsity of the dogma of inerrancy. Apart from the dogma of the inerrancy of the Bible, the question of the date of the origin of man has obviously no theological significance whatsoever.

Sharp and unqualified as the contradiction appears between the scientific teaching of the antiquity of man and the text of Scripture, some exegetes have yet insisted that the great antiquity of man may be admitted without denying the doctrine of inerrancy. The chronology, it is said, may be lengthened as much as may be necessary by the simple supposition that some links are omitted in the chain of genealogy. It must seem to a mind unbiased by dogmatic prepossessions that those exegetes use words in a peculiarly accommodated sense. It is quite intelligible that a writer who was not inerrant might have incomplete information in regard to a line of genealogy, and might describe one person as the son of another when he was really his grandson or his great-grandson; and it is quite possible that many, if not all, of the names mentioned in those genealogical tables may be names of actual persons who were in one hereditary line, though various links in the chain of the generations have been omitted. Such a genealogical table, as the work of a writer capable of error and possessed of incomplete knowledge, would be perfectly intelligible. But, when a learned exegete tells us that an *inerrant* writer can

declare that a man lived an hundred sixty and two years and begat his great-great-great-grandson, the common mind is left wonderingly to inquire whether words have any definite meaning or not.

Another point in which geology and other sciences require modification of traditional beliefs in regard to Scripture history, is the Noachian Deluge. As we have already seen,* the Noachian Deluge was formerly supposed to have been an event of tremendous significance in the history of the earth as well as in the history of man. For about a century and a half the opinion was widely held that the whole mass of the fossiliferous rocks was deposited by the Noachian Deluge. Even after that notion had been dissipated, the belief was still retained that the waters of the flood actually covered the whole surface of the earth. In the eighteenth century it was a common undertaking of Biblical students to calculate the cubic contents of the ark, and to prove that its capacity was ample for the residence of pairs of all species of animals, and for the storage of a supply of food for them for a number of months. So long as people neither knew nor cared about the animals of other parts of the world than Europe and western Asia, nor about the countless multitudes of species of insects and others of the smaller and less conspicuous forms of life even in that region, these conclusions looked sufficiently plausible. But, in the light of our present knowledge of the number and distribution of animal species, the preservation

---

* See pages 45, 90.

of representatives of all terrestrial species in the ark becomes absolutely incredible. The conception of sloths, tortoises, and snails promenading in pairs across the Atlantic Ocean from South America, to find at last a home in the ark somewhere in the valley of the Euphrates, involves a combination of conditions whose improbability is simply colossal. From the standpoint of dynamical geology, the supposition of such crustal movements as would cause a universal submergence of continents and mountains at any time in recent geological history would be utterly incredible.

But, while the supposition of a deluge universal as regards the earth is utterly incredible, it is, of course, perfectly possible that there may have been at an early period of human history a deluge universal as regards the human race. Whether we suppose the race to have originated from a single pair, in accordance with Hebrew tradition, or (as on biological grounds would be far more probable) from a considerable number of individuals evolved to the condition of humanity at about the same time, it is probably true that the race in its origin was confined within pretty narrow geographical limits, and that its wide diffusion over the surface of the earth is the result of later migration. There would be, then, nothing in itself incredible in the notion that, before the race had become widely diffused, a deluge, such as might be caused by earthquake waves or even by a violent hurricane, might destroy the whole race, with the exception of a few individuals or a single family, who might find safety in

some sort of a boat. Whether there is any adequate evidence for believing in the actual occurrence of such a catastrophe, is another question.

The belief that the Noachian Deluge was universal as regards man, is based chiefly upon the existence of wide-spread traditions of an event more or less similar to that recorded in Genesis. All the way, in fact, from China to North and South America, we find traditions of a deluge in which the whole human race was destroyed, with the exception of a single family or a small number of persons who escaped on some sort of boat or raft. In very many cases the tradition includes also the idea that those few survivors were enabled to escape by some sort of supernatural warning which they owed to the special favor of the gods. It has been hastily assumed that all these deluge traditions must refer to the same event. Even where the mythology of a single people, as in the case of the ancient Greeks, preserves the tradition of several distinct deluges, it has been assumed that they must all be considered as more or less distorted representations of the one Noachian Deluge. This assumption, however, is certainly not supported by any adequate evidence, and is, in all probability, false. In an early stage of civilization, when there was little opportunity for intercommunication between the inhabitants of different districts of country, the few survivors of a district which had been inundated and mostly depopulated by an earthquake wave or some other catastrophe, would naturally start a tradition in which they would be rep-

resented as the sole survivors from a universal destruction of the human race. In some cases, there are not wanting in the deluge traditions local features which pretty plainly indicate that the event upon which the tradition was founded occurred in a locality widely removed from the scene of the Noachian Deluge. The Chinese tradition of a deluge is, in all probability, due to one of the numerous migrations of the River Hoang Ho across its vast delta plain. The movements of that uneasy river have again and again within historic times caused immense loss of life. When two peoples are blended into one by conquest and subsequent intermarriage, the traditions of one race are often to a greater or less extent adopted by the other. There is reason to suspect that the traditions of a deluge in some savage tribes are due to the influence of Jesuit missionaries, who, in the palmy days of that order, penetrated to the most distant parts of the earth, and who, though they did not succeed in producing very enlightened Christians or developing a very high style of Christian civilization, did succeed in teaching effectively the stories of Hebrew tradition. Even if a deluge tradition were universal, the fact would not prove a universal deluge.*

But, though deluge traditions are widely diffused, they are by no means universal. No deluge tradition has been reported from any Negro people, except the inhabitants of the Andaman Islands, who are prob-

* See the excellent analysis of deluge traditions in Hastings, *Dictionary of the Bible*, art. *Flood*, by F. H. Woods.

ably closely related to the Negro race. The ancient Egyptians, who, though they lived in Africa, were not of Negro but of Caucasian race, had no deluge tradition. There is, then, obviously no satisfactory evidence of a universal deluge afforded by tradition.

It may be affirmed without any hesitation that a deluge universal as regards the human race, at the date given by the traditional chronology, B. C. 2348, is utterly incredible. As has been noticed in the discussion of the antiquity of man, it is probable that the civilizations of Babylonia, Egypt, and China extend back to or beyond that date. A universal deluge could only have been possible at a time vastly earlier. The universality of the Noachian Deluge as regards the human race can be maintained only on the supposition that the chronology of the fifth chapter of Genesis, based on the genealogy from Adam to Noah, is substantially correct, or that its error is on the side of a time estimate too long rather than too short; and that, on the other hand, the chronology of the eleventh chapter of Genesis, based on the genealogy from Noah to Abraham, gives a time estimate which is only a small fraction of the true duration. It is needless to say that this twofold supposition is extremely improbable. On general principles, the earlier genealogy should be the less, rather than the more, nearly complete.

It is evident, in general, that we have in the book of Genesis nothing that approaches the character of reliable history till about the time of Abraham. The comparison of the teachings of science with the record

of Genesis leads us to the conclusion that the date and method of creation of the earth and of man, and the early history of the human race, are not matter of divine revelation, but matter for scientific investigation. An agreement between the results of scientific investigation and Hebrew tradition is neither to be sought nor expected.

III.—The Unity of the Universe

The third and most important of the characteristic ideas entering into the scientific conception of the universe is that of the unity of the universe. We have already referred to Newton's discovery of universal gravitation, which has probably been more important in its influence upon human thought than any other single discovery in the whole history of science. Newton's discovery was the completion and culmination of that series of astronomical discoveries which gave to mankind a true view of the relation of the earth to the heavenly bodies, and a somewhat adequate conception of the immensity of the universe. But that discovery of Newton's was perhaps even more important in another aspect as the beginning of the development of the idea of the unity of nature.

In the century just ended, the investigations of science have revealed, with a fullness not dreamed of before, a threefold unity in nature—a unity of substance, a unity of force, and a unity of process.

In two ways we are able to learn somewhat of the chemical constitution of parts of the universe outside of the earth. The extra-terrestrial origin of meteorites has come to be universally admitted; and the fact that those wanderers through space contain no element which is not known to terrestrial chemistry is profoundly significant in its teaching of the unity of sub-

stance throughout the universe. The spectroscope has afforded us a method of investigating the constitution of luminous bodies, and so has given us some knowledge of the chemical composition, not only of the sun, but also of the immensely more remote stars and nebulæ. In all these bodies whose light has been subjected to spectrum analysis, elements have been discovered which are well known upon the earth. In the solar eclipse of 1868, a conspicuous yellow line was observed in the spectrum of the solar protuberances which could not be identified with any terrestrial element then known. The hypothetical element to which that yellow line was due was named helium. Within the last few years that element has been recognized in several rare minerals which occur upon the earth. Thus it appears that one of the rarer elements in terrestrial chemistry was first discovered in the sun.

The Conservation of Energy*

The idea of a unity of force in the universe has taken shape in the modern scientific doctrine of the conservation of energy.

That we may understand the significance of the series of scientific researches which have culminated in the development of the doctrine of the conservation of

---

* Whewell, *History of the Inductive Sciences*, gives fully the history of the phlogistic theory, of the development of modern chemistry, and of the undulatory theory of light. Tyndall, *Heat Considered as a Mode of Motion*, gives a brilliant account of the dynamical theory of heat. Youmans, *The Correlation and Conservation of Forces*, gives in convenient form a collection of early expositions of the doctrine of conservation of energy. See also Stewart, *The Conservation of Energy*.

energy, let us ask ourselves what happens in the familiar occurrence of the combustion of wood, or coal, or any other combustible. There is a conspicuous evolution of light and heat, the original substance disappears, but some sort of residue is left, which may, according to circumstances, be solid, liquid, or gaseous. But what is the real nature and meaning of the process? Some of the ancient philosophers, in their semi-mythological mode of interpreting the facts of nature, said that the element of fire, imprisoned in the combustible substance, was set free, and escaped into the empyrean, the lofty abode of the pure and changeless element of fire.

The first definite scientific theory of the process of combustion was given by Stahl in 1697. According to his view, the essential thing in the process of combustion was the escaping from the combustible of a substance called phlogiston. According to the phlogistic theory, the phlogiston could escape from one body only when some other body was ready to absorb it and enter into combination with it. In ordinary cases of combustion, the phlogiston which left the various combustibles passed into the atmosphere, which was supposed to be very far from saturation with phlogiston. When oxygen was discovered, it was found to be a much more energetic supporter of combustion than ordinary atmospheric air. This was at once explained by the supposition that oxygen was destitute of phlogiston, or at least more nearly so than ordinary air, and possessed therefore a more intense

avidity for that substance. Oxygen was accordingly named by Priestley, its discoverer, "dephlogisticated air." It was, however, a puzzling and inexplicable fact that in some cases it could readily be shown (we now know it is always true) that the substance resulting from the combustion is heavier than the original combustible. It was certainly a paradoxical condition that the loss of one of its constituents should increase the weight of a body.

The abandonment of the phlogistic theory and the establishment of the modern chemical theory were chiefly due to the researches of the French chemist, Lavoisier, whose results were given to the world in a series of memoirs commencing about 1775. As everyone now knows, the chemical change which takes place in ordinary cases of combustion is not the loss of any part of the substance of the combustible, but the union of that substance with oxygen. In Lavoisier's experiments, mercury was made alternately to take on oxygen, being thus converted into the red oxide of mercury, and to give off its oxygen, and thus be restored to its metallic condition. Since the time of Lavoisier there has been no question about the purely chemical side of the process of combustion. We have learned that in all physical and chemical changes there is neither creation nor destruction of matter. Complex molecules may be broken up into simpler constituents, or elements may be united into complex molecules; but in all chemical changes the quantity of matter remains constant. Every chemical process may be expressed

in the form of an equation, in which the atomic symbols on one side of the equation are so grouped as to represent the arrangement of the atoms before the reaction in question, and the symbols on the other side of the equation are so grouped as to represent the arrangement of the atoms after the reaction. The number of atoms of each element will be identical on the two sides of the equation. Thus we find perpetual change in form, but neither increase nor diminution in the quantity of matter. That, in the broad view, was the truth taught the world by the researches of Lavoisier.

But the purely chemical theory of Lavoisier gave no account of the heat and light which are so frequent accompaniments of chemical change, and which, in ordinary cases of combustion, are the most conspicuous phenomena of the process. It was a long time before any satisfactory explanation of these phenomena and of their relation to chemical change could be given. In the meanwhile, heat and light haunted like ghosts alike the laboratory of the chemist and physicist and the workshop of the artisan. Like their fellow ghost, electricity, they were remarkably conspicuous in their manifestations, though utterly inexplicable in their nature. They were supposed to be material things, though destitute of weight. The most delicate balance could detect no difference between the weight of a piece of cold iron and that of the same piece of iron when hot. They were called "imponderable bodies," or "imponderable agents," the latter phrase being a

convenient one, as not committing its user to any theory in regard to their nature.

But, though the prevalent belief at the end of the eighteenth and the beginning of the nineteenth century was that light, heat, and electricity are material bodies, their lack of power to respond in any measurable degree to the attraction of gravitation could not but suggest doubts in regard to their material nature. As long ago as 1690 Huyghens had taught that light was an undulation. His contemporary, the great Sir Isaac Newton, seriously considered the question whether light might not be some form of undulatory movement, but concluded that the phenomena with which he was acquainted were, on the whole, best accounted for by the supposition that light consisted of extremely minute material particles. The mighty influence of Newton's great name served in this case to maintain a false theory in general acceptance for a century and a half. It was not, indeed, until the beginning of the nineteenth century that the undulatory theory of light attracted general attention. The views of Huyghens were for the most part ignored until they were presented in new form by Thomas Young in 1801 and by Fresnel in 1815. Dr. Young was well-nigh a universal genius, busying himself with all sorts of investigations, from the theory of light and color to the deciphering of Egyptian hieroglyphics. Fresnel, though possessed of less varied and versatile genius than Young, was a consummate mathematician, and by his great mathematical ability was enabled to develop the undulatory

theory of light in a form so ingenious and beautiful as to compel the respectful attention of all who were competent to understand his reasoning. For many years, however, after the publication of the first of Fresnel's memoirs, the conflict between the two theories continued. But the undulatory theory was steadily gaining, and the corpuscular theory losing ground. As the knowledge of the phenomena of light increased, and it became necessary to account for polarization, double refraction, and other phenomena which were investigated, it was found that they could be accounted for simply and consistently on the undulatory theory, while the corpuscular theory could only account for them by the accumulation of cumbersome and unsatisfactory hypotheses. The story of the progress of the undulatory theory of light was analogous to that of the progress of the Copernican astronomy. The Ptolemaic astronomy could indeed invent some combination of epicycles to formulate each newly discovered planetary irregularity; but no complex supplementary hypotheses were required by Kepler's laws and Newton's theory of gravitation.

As a consequence of Fresnel's theory, Sir William Rowan Hamilton predicted the remarkable phenomena called respectively external and internal conical refraction, which had never been observed until an experiment was devised by Humphrey Lloyd to test Hamilton's prediction. Such prediction of phenomena hitherto unobserved is, of course, very strong confirmation of the truth of a theory. But it was not until 1850

that a crucial experiment was devised by which a definite conclusion in regard to the two theories could be reached. The familiar fact that rays of light passing from a rarer into a denser medium are refracted toward a line perpendicular to the limiting surface, was explained plausibly enough by each of the two contending theories; but the explanation on the basis of the corpuscular theory involved the assumption that light moves more rapidly through the denser than through the rarer medium, while the explanation given by the undulatory theory involved the contradictory assumption that light moves less rapidly through the denser than through the rarer medium. If, then, an experiment could be devised which would measure the velocity of light respectively in air and in water, the result would be a decisive victory of one or the other of the contending theories. The motion of light is so inconceivably rapid that its measurement within a small distance such as could be available for experiment seemed almost impossible; but the difficulties were overcome by the experimental skill of Foucault in 1850, and the definite determination that the velocity of light in water is less than its velocity in air established conclusively the undulatory theory.

In the case of heat, as in the case of light, it was long ago suspected that it might prove to be a mode of motion, but the series of investigations by which that conclusion was established belongs almost exclusively to the first half of the nineteenth century. As long ago as 1620, Lord Bacon, in his "Novum Or-

ganum," declared heat to be a species of motion. Bacon tells us explicitly that he does not mean that heat can be produced by motion, or that motion can be produced by heat; but that he means absolutely that heat is a form of motion. But it was not until the very close of the eighteenth century that the question of the nature of heat was brought prominently before the scientific world by the experiments of Count Rumford. Count Rumford was an American whose name was Benjamin Thompson. He left his native country because he took the loyalist side on the outbreak of the American Revolution; and in 1798 he was living in Munich, and was in the service of the Bavarian Government as Minister of War. He had charge of the manufacture of cannon for the Bavarian army, and his attention was specially called to the heat produced in the boring of cannon. The fragments of metal that came out of the bore were observed to have a high temperature, and Rumford began to reason as to the source of the heat. Those chips of metal had apparently suffered no change, having the same capacity for heat as other pieces of similar metal. In some of his experimental investigations, Rumford caused a piston to revolve in a cylinder enclosed in a box of water, and heated the water to boiling by the friction of the piston in the cylinder. There appeared to be no limit to the amount of heat which might thus be developed by friction. The inference which Rumford drew from his experiments, and which seems unquestionably a sound one, may be stated in his own words: "Anything

which an insulated body or system of bodies can continue to furnish without limitation cannot possibly be a material substance." In the early part of the nineteenth century, Sir Humphry Davy was experimenting in other ways with reference to the question of the nature of heat, and reached the same conclusions as Rumford. The work of Rumford and Davy found its completion in the determination of the mechanical equivalent of heat by Joule in 1843. Joule determined by a series of experiments that the amount of heat that will raise the temperature of a pound of water one degree Fahrenheit is the quantitative equivalent of the mechanical work of lifting a pound 772 feet, or 772 pounds one foot, in opposition to gravitation. In technical language, the mechanical equivalent of heat is said to be 772 footpounds. This definite quantitative result is obviously a great step in advance of the purely qualitative conclusions of Rumford and Davy. They had reached the conclusion that heat could not be a material body, and must therefore be some sort of motion. Joule established an exact quantitative ratio between that form of molecular motion which we call heat, and the forms of molar motion with which we are acquainted in ordinary mechanics.

It is fair to say that, in the announcement of the mechanical equivalent of heat, Joule was slightly anticipated by a German physician named Mayer. Mayer's conclusion, published in 1842, was reached by a very different method from that of Joule, and was based in part on somewhat speculative reasoning.

Joule's conclusion was based upon a course of very rigorous experimentation. It has generally been felt that the patient experimentation of Joule established the important doctrine of the mechanical equivalent of heat on a sounder basis than the brilliant speculation of Mayer. And so, by common consent, in spite of the priority of Mayer, the number 772, which expresses the ratio between heat and mechanical motion has been called by the name of Joule, and is expressed in formulas by the initial of his name.

Thus, about the middle of the nineteenth century, light and heat were both conclusively shown to be not material bodies, but modes of motion. We have indeed come to regard light and heat only as different phenomenal manifestations of the same energy. From the sun and from other incandescent bodies, waves of radiant energy stream out constantly in vast complexity, ranging in wave-length through a very long gamut. All these waves of energy, long and short, are capable of producing the phenomena of heat. Those waves of energy which fall within a certain limit as regards wave-length, are capable, in addition, of exciting, when they impinge upon the retina of the eye, the sensation of light and color; but the difference between these luminous waves and the waves of greater and lesser wave-length beyond the limits of the visible spectrum is only physiological. It is only that our eyes are able to derive the sensation of color from waves which fall within those limits of wave-length and not from longer or shorter waves.

Joule and Mayer proved a definite quantitative relation between heat and mechanical motion. The truth which they proved was quickly expanded into the broad induction that all forms of physical energy are thus quantitatively related and are mutually convertible. The molar motion of ordinary mechanics, the molecular movements of heat and electricity, the atomic movements which form the subject of chemical science, are all quantitatively related and mutually convertible. Heat may be developed by friction of masses of matter, or by collisions of atoms which rush together in chemical combination. The energy derived from the combustion of carbon in a steam engine may move a train of cars or drive the machinery of a factory, or may be converted into electricity, and that electricity in turn may be converted by an electric motor into mechanical motion. And thus is reached a broad conclusion in regard to energy parallel to that reached by Lavoisier in regard to matter. As Lavoisier showed that in all chemical changes there is neither creation nor destruction of matter, but only rearrangement, so we now believe that in all physical and chemical changes there is neither creation nor destruction of energy, but endless metamorphosis of energy into different forms.

In these revelations of physics there comes back to us in a new form the truth which was represented in distorted form by the old phlogistic theory, and which was ignored by the purely chemical theory of Lavoisier and his followers. The believers in the phlogistic theory recognized in the emission of light and heat from

the burning combustible a sign that something was going out of it. That something they wrongly interpreted as a material substance. There is indeed something which the burning combustible loses; but that something is no material substance, but potential energy.

It is impossible to recognize the truth of the conservation of energy in the realm of inorganic matter without raising the question whether that law also holds good in regard to the processes of the living body as seen in plants and animals. It had been in general vaguely supposed that the processes which go on in living bodies were radically different from the purely physical and chemical processes of the inanimate world; and, until the middle of the nineteenth century, such expressions as "vital force" were in frequent use, to express the unknown agency to which were due the peculiar phenomena of living beings. But the genius of Mayer had scarcely got hold of the doctrine of the mechanical equivalent of heat before he perceived the far-reaching conclusions to which the theory of the conservation of energy would lead. Only three years after his announcement of the mechanical equivalent of heat, he published a remarkable paper on the movements of animals and plants, in which he maintains that the energy manifested in those movements is derived from the chemical changes that take place in the food. He had, in fact, already grasped the modern doctrine that the animal body is not a creator of force, but only a machine by which the energy of chemical

action is converted into the energy of heat and mechanical motion.

Mayer's essay attracted comparatively little attention. It was published in a rather obscure German periodical, and found few readers outside of Germany; and the world was not quite ready to accept its far-reaching conclusions. The classical memoir "On the Conservation of Force," by Helmholtz, was published in 1847. In the conclusion of this essay, the application of the law of conservation to the processes going on in living bodies was briefly but distinctly announced. Still earlier Helmholtz had been engaged in researches on the consumption of matter and on the evolution of heat in muscular action, which foreshadowed the great generalization. William B. Carpenter, the English physiologist, published his essay "On the Mutual Relations of the Vital and Physical Forces" in 1850.* A few years later, in 1859, substantially the same views were published in this country by Joseph Le Conte,† who, though chiefly known as a geologist, made important and valuable contributions to other branches of science.

According to our present views of the dynamics of living bodies, the growth of vegetation, which under ordinary conditions takes place only under the influence of sunlight, is due to the radiant energy of the

* *Philosophical Transactions*, 1850. Another essay by Carpenter, published a few years later, is contained in Youmans, *The Correlation and Conservation of Forces*.

† *American Journal of Science and Arts*, 2d series, vol. xxviii, p. 305. Le Conte's article, in revised form, was republished in the appendix of Stewart, *The Conservation of Energy*.

sunbeams. The energy of the sunbeams tears asunder the molecules of carbon dioxide in the atmosphere, and the carbon is stored up in vegetable tissue, while the oxygen is given back to the atmosphere. In the storing of carbon in the vegetable tissues there is also a storing of potential energy; and in its subsequent oxidation, in the plant itself or in an animal which has eaten the plant, the potential energy may become energy of heat or of motion. The germination of the seed, which takes place in subterranean darkness, the varied movements which are exhibited in some degree by plants and in vastly greater degree by animals, the development of heat which maintains the temperature of many organisms far above that of the surrounding medium, are all the result of the oxidation—the virtual combustion—of the combustible materials stored up in vegetable and animal tissues. The animal body is, then, a machine in which, as in the steam engine, the combustion of carbon and other combustible elements is made to furnish energy which reveals itself in heat and mechanical motion. In one respect, indeed, the animal machine is very different from the steam engine. It is a self-repairing machine. It is as though we could feed the steam engine, not only with coal for fuel, but with iron and brass and other materials which might be necessary to repair the waste of the working parts of the machine. So, in the animal body, a part of the food serves as fuel for the production of energy, but another part serves to rebuild the continually wasting tissues of the body, and so to keep the machine in repair.

But, though the animal body is vastly more complex than any machine of human invention, there is no reasonable doubt that the law of the conservation of energy holds sway in the animal body precisely as in other heat engines.*

But we must recognize not only that muscular action comes within the scope of the law of the conservation of energy, but that the same is true of the more subtile processes involved in the operations of nerve and brain. It has long been known that there are certain obvious analogies between nerve force and other physical forces. The nerve force is not a spiritual potency which diffuses itself without relation to material conditions. It is transmitted along the nerve with a measurable velocity, as electricity is transmitted along a conducting wire. The velocity of the nerve force is, in fact, considerably less than that of the transmission of electricity along a good conductor, being in warm-blooded animals only about one hundred feet per second, and in cold-blooded animals considerably less.

---

* The most nearly complete experimental proof of the application of the law of conservation of energy to the human body has been obtained by the experiments with the Atwater-Rosa calorimeter, conducted by Professors Atwater, Rosa, and Benedict, and their associates, in the laboratory of Wesleyan University. The plan of these experiments involved very accurate determination of the chemical composition and potential energy of the food consumed, the amounts of carbon and nitrogen discharged from the body, and the amount of energy given off by the body as heat and mechanical work. The average result of forty-five experiments, extending over periods amounting in the aggregate to one hundred and forty-three days, was that the energy determined as given off from the body did not differ by any measurable quantity from the calculated potential energy of the materials oxidized in the body. A discussion of some of these experiments may be found in *Physical Review*, vol. ix, pp. 129, 214, vol. x, p. 129; *Bulletin* No. 109 of the Office of Experiment Stations, U. S. Department of Agriculture. The latest and most complete account of these investigations is given in *Bulletin* No. 136 of same series.

Somewhat is known also in regard to the physical changes going on in the brain. The blood coming from the brain has a higher temperature than the arterial blood, and contains less oxygen and more carbon dioxide.* Some part of the potential energy of the nutritive materials supplied to the brain is converted into heat. Increased activity of thought or excitement of feeling is accompanied by a more rapid blood current through the brain. The more rapid chemical changes find expression in a rise of temperature which can be detected by the application of thermo-electric apparatus to the outside of the head.† The chemical changes going on in the active brain are accompanied by changes in the appearance of the cells of the gray matter, which are perfectly recognizable under the microscope when cells from the brains of animals killed after a night's sleep are compared with cells from the brains of animals of the same species killed after a day's activity.‡

The conception of the unity of nature which is involved in the doctrine of the conservation of energy extends not only through all space, but through all time. The vegetable tissues whose remains, preserved from complete decomposition, are stored up in the form of coal, were produced by the agency of the sunbeams that shone upon the earth tens of millions of years ago in the Carboniferous era. Then as now the en-

---

* H. H. Donaldson, in Howell, *American Text-book of Physiology*, p. 736.

† J. S. Lombard, in *Proceedings of Royal Society of London*, vol. xxvii, p. 462; Ladd, *Elements of Physiological Psychology*, p. 242; Luys, *The Brain and its Functions*, p. 76.

‡ H. H. Donaldson, in Howell, *American Text-book of Physiology*, p. 631.

ergy of the sunbeams tore asunder the molecules of carbon dioxide in the atmosphere, and stored up the carbon in living tissues; then as now that energy of the sunbeam was converted into the potential energy of the carbon atoms. And so, when we warm our dwellings by the burning of coal, and light them by the burning of gas derived from coal, or by electricity produced by a dynamo which is run by a coal-fed steam engine, we are warming and lighting our dwellings with the sunbeams of the Carboniferous era. The flux of energy from one form to another is continuous, but the stock of energy remains unchanged through measureless eons.

The only point in which the doctrine of the conservation of energy has been supposed to come into collision with theological belief is in regard to the application of the doctrine to the actions of the nervous system. When we come to recognize that the processes which go on in the human brain, and which reveal themselves in our states of consciousness, are correlated with purely physical and chemical changes which go on in the inorganic world, the question is inevitably suggested, whether there is any other than a material element involved in those cerebral changes; whether there is a spiritual entity distinct from the material organism, while using that material organism as a means to its ends, or whether our psychological experiences are simply and solely affections of the material organism. It will be convenient for us, however, to defer the discussion of this question for the present.

denborg, Buffon, and other writers in the eighteenth century. Though Laplace had been anticipated by Kant, and in some degree by others, the theory is most commonly accredited to him; and rightly, for the credit of a scientific theory belongs not to him in whose mind the idea first arises as a conjecture, but to him who gives to the idea so definite a form, and who supports it with such wealth of knowledge, as to secure for it consideration and acceptance.

The evidence upon which Laplace based the nebular theory is found in the remarkable coincidences which exist in the movements of the planets. A certain amount of coincidence in the planetary movements would, indeed, be necessitated by the Newtonian theory of gravitation, independently of any conception as to the origin of the planets. Whatever the origin of a planet might have been, the attraction of the central sun would constrain it to move in an orbit whose form would be some one of the conic sections, and to move with a velocity conforming to the law that the radius vector describes equal areas in equal times. But the actual movements of the planets show a far greater amount of coincidence than this. Their orbits are all ellipses of very small eccentricity, departing but little from the form of the circle. With the exception of some of the asteroids, their orbits are nearly in the plane of the sun's equator. They all revolve in the same direction in which the sun rotates. The planets all rotate upon their axes; and the planes of their rotation, with the exception, probably, of Uranus, are

The same question will be suggested to us from another point of view, when we come to consider the bearings of the doctrine of organic evolution; and the question can be better discussed when we have before us all the scientific facts which may be supposed to have some bearing upon it.

Evolution

We now come to the consideration of the third phase of the idea of the unity of nature characterstic of modern science; namely, the continuity of process in the history of nature. The one word which expresses this idea in modern scientific thought, and which, more than any other word, gives utterance to the distinctive characteristic of the intellectual life of our time, is the word "Evolution." The modern development of the idea of evolution will be considered in three phases: first, astronomical evolution; second, geological evolution; third, biological evolution.

THE NEBULAR THEORY*

The doctrine of evolution in astronomy is represented by the nebular theory.

The general conception of the origin of the solar system which we call the nebular theory, was independently proposed by Kant in 1755, and by Laplace in 1796. Speculations more or less crude, tending somewhat in the same direction, may be found in Swe-

* Ball, *The Earth's Beginning;* Gore, *The Visible Universe;* Newcomb, *The Stars, a Study of the Universe;* Winchell, *World-Life, or Comparative Geology.*

nearly coincident with the planes of their revolution. With the exception, probably, of Uranus and Neptune, the direction of their rotation is the same as the direction of their revolution. Most of the planets are accompanied by a satellite or by a number of satellites. The direction of revolution of the satellites is believed to be in every case the same as the direction of the rotation of their respective planets, and the planes of the orbits of the satellites are nearly coincident with the equatorial planes of the planets. These coincidences are exceedingly suggestive of the idea that the planets were once parts of a common mass, and that their revolution around the sun is an inheritance of the rotation in which they shared when still included in the parent mass. That is, indeed, in its most general form, the idea of the nebular theory.

According to Laplace, the earliest condition of the solar system of which science gives us any account is that of a heated gas diffused through an immense space extending even beyond the orbit of Neptune. If the particles of such a gas were subject to the mutual attraction of gravitation, the resultant of all the attractions would be a movement of each particle towards the common center of gravity—a condensation of the mass. If the further supposition is made of independent movements of the particles in various directions in the initial stage of the history (whatever may have been the cause or causes of those movements), the resultant of those independent movements, in connection with the gravitational tendency towards the center, would

be a revolution of each particle around the center. Unless the movements of revolution in opposite directions exactly balanced each other—a supposition whose improbability would be well-nigh infinite,—the aggregate effect of the tendency of each particle to revolve around the center would be the rotation of the entire mass.

As condensation progressed, the rotation would increase in velocity, since every particle must conform to the law that the radius vector describes equal areas in equal times. With increasing velocity of rotation there would come an increased centrifugal force. After a time, at the periphery of the rotating mass, where necessarily the force of gravitation would be weakest, the centrifugal force would overbalance the force of gravitation. Peripheral portions of the mass would then be left behind, as the central mass, still condensing, shrank away from them. The origin of the planets is to be found in these peripheral portions of the nebula left behind from time to time by reason of increasing centrifugal force. It is obvious that there would be three possibilities in regard to the subsequent development of those peripheral portions of the nebula which were thus left behind. If the mass was almost perfectly symmetrical and homogeneous, it might happen that the particles left behind at the periphery would be so uniformly distributed all around the central mass that the ring of particles thus formed would be able to maintain itself as a permanent ring. It is obvious, however, that so perfect symmetry in the arrangement

of the particles left behind by the contracting spheroid would be likely to occur only as a rare and exceptional phenomenon. It would seem probable that, in the great majority of cases, the peripheral ring would quickly break up into fragments, which would become aggregated into a single spheroidal mass, or perhaps, under different conditions, into a number of spheroidal masses. The spheroids thus formed would be the planets. The revolution of the planets around the sun is thus seen to be necessitated by the motion of rotation which they had formerly shared with the central mass. It can be shown that a planet thus formed would rotate on its axis as well as revolve around the sun, and that under some conditions the rotation would be in the same direction as the revolution, and under other not improbable conditions the rotation would be in the direction opposite to the revolution. The exceptional movements of Neptune and Uranus are thus readily accounted for. As a planet rotated and contracted, it would in turn leave behind peripheral portions, which would form satellites, precisely as the primary planets were formed by the leaving behind of peripheral portions of the sun. In the vast majority of cases, both of primary planets and of satellites, the whole amount of the material left behind at each epoch of planetary formation aggregated itself into a single spheroid. In the evolution of the primary planets we have the one exceptional case of the asteroids, in which the material left behind aggregated itself not into a single spheroid, but into a large number of spheroids, forming many

small planets instead of one large one. In the evolution of the satellites from the planets, we have the one wonderful case of Saturn's rings, in which the material abandoned at the periphery of the rotating mass was so exquisitely balanced as to maintain itself permanently in the condition of a ring. It is of course involved in the form of the nebular theory held by Laplace that the planets were formed in the order of their distance from the sun, commencing with the most distant. Neptune was the first-born of the children of the sun, and Mercury the youngest of its children.

In the preceding paragraph, the nebular theory has been stated substantially in the form in which it was proposed by Laplace. There is reason, however, to believe that some modifications will render the theory more accordant with the facts and probabilities of astronomical science to-day. In the first place, Laplace's supposition that the material left behind from time to time at the periphery of the contracting nebula would always or generally be a complete ring, assumed too great a degree of symmetry and homogeneity in the nebula. It seems more probable that, at least in the majority of cases, there would be a decided excess of matter on one side of the axis of rotation, forming a more or less decided protuberance or hump, and that the material left behind when the centrifugal force overbalanced the force of gravitation would be derived, not from the whole periphery of the nebula, but from that protuberance. In such cases, of course, the aggregation of the mass thus separated into a single spheroid

would be more quickly accomplished than in the process assumed by Laplace.

In the second place, Laplace's supposition that the initial temperature of the nebula was extremely high, is certainly unnecessary, and probably not true. Whatever the initial temperature may have been, the effect of condensation would be the production of heat. So long as the condensation was rapid, the gain of heat, as the result of condensation, would exceed the loss of heat by radiation into space. The temperature, therefore, would rise, in the mass as a whole, or in any isolated portion of that mass, so long as it was undergoing rapid condensation. When, in any particular portion, the condensation had reached such a stage that further condensation became very slow, the loss of heat by radiation would overbalance the slow gain by further condensation, and the temperature would fall. The thermal conditions of different parts of the solar system are so exactly in accord with this phase of the theory as to furnish a strong confirmation of the truth of the theory. The earth and probably all the planets have reached such a stage of condensation that their rate of contraction at present is very slow. They are, therefore, probably cooling globes; and, so far as we can get evidence as to their respective temperatures, the largest bodies have the highest temperatures. The extremely dense atmosphere of Jupiter, the largest of the planets, with its vast ocean of cloud, apparently hiding completely the surface of the planet, bears witness to the very high temperature of that planet. Jupi-

ter, in fact, appears to be in the condition in which the earth was once, when all the ocean existed in the atmosphere, chiefly in the form of vapor, but in part condensing into cloud. While in Jupiter, the largest of the planets, we thus find indication of a temperature much higher than that of the earth, telescopic observations of the moon indicate that it has cooled to a much lower temperature than that of the earth. In that process of cooling it has almost or entirely lost its original supply of atmospheric gases and of water. The atmosphere and water which it probably once possessed, may have been withdrawn into the pores of its solid mass, or have entered into stable forms of chemical combination. Some of the water perhaps exists at the surface in the form of ice. While it is probably true of all the planets that they have long since passed their maximum of temperature and are now cooling, it is uncertain whether the temperature of the sun at present is rising or falling. The density of the sun is small, and there is reason to believe that a large part of its material is gaseous. It is, however, a gas in a state of extreme condensation, and is at present contracting very slowly. Our knowledge is insufficient positively to decide whether its gain of heat by the slow contraction going on is greater or less than its loss of heat by radiation.

There is a tendency also to the opinion that, in its initial condition, the nebula was not a uniform gas, but rather a swarm of meteors. The motions of these bodies in space would result in frequent collisions, and the effect of the collision of meteors would be to

produce so great an amount of heat as to convert a greater or less part of their substance into gas. The effect of the condensation of the nebula in producing a gradual elevation of temperature would be the same, whether we suppose the material to have been a gas or a meteoric swarm. In the former case, with increasing condensation the collisions of molecules would be more frequent; in the latter case, with increasing condensation the collision of the meteors would be more frequent. Whether the collisions were of molecules or of masses of sensible magnitude, makes no difference in the general result. In either case, the greater frequency of collisions would produce a continuous elevation of temperature.

It is uncertain, too, whether the planets were evolved in the order of their relative distances from the sun, as supposed by Laplace. It is believed by many astronomers to be possible that condensation may have taken place at various points within the mass of the nebula, so that planetary evolution may have been going on simultaneously at various distances from the center. There is, moreover, considerable reason to believe that the genesis of the moon was an exceptional case, differing considerably in its method from that of other secondary planets and that of the primary planets.*

The evidence upon which Laplace relied for the support of the nebular theory was found, as we have seen,

* G. H. Darwin, *The Tides, and Kindred Phenomena in the Solar System*, pp. 282, 339.

in the coincidences of the planetary movements. In 1811, Sir William Herschel called attention to the evidence furnished in support of some form of nebular theory by the presence of nebulæ and nebulous stars. Many nebulæ are readily seen with low powers of the telescope, appearing as faint cloudlets of diffused light. In some cases a bright point of light is seen somewhere near the center of the nebula, and then the body is called a nebulous star. It was urged by Herschel that these phenomena indicate that in various parts of the universe at the present time there are masses of matter in some such condition as that in which the solar system is believed to have been at a remote period in the past. The views of Sir William Herschel seem not to have attracted very much attention at the time they were first published, and some decades later they appeared to be considerably discredited by new discoveries. In 1842, Lord Rosse constructed a colossal reflecting telescope of higher magnifying power than any telescope which had been previously used. The examination of many nebulæ with that great instrument showed that they were simply clusters of stars, whose immense distance or relatively small size rendered it impossible to recognize the individual stars with lower magnifying powers. It was a very natural conclusion, but a hasty one, and one which we now know to be erroneous, that it only needed a larger telescope to resolve all the nebulæ into stars. We now feel sure that no telescopic power could resolve all nebulæ into stars, for the simple reason that some of them are not stars.

The spectroscope serves to distinguish the light of incandescent gases not extremely condensed, from the light of incandescent solids or liquids, or from that of gases in an extreme state of condensation. The ordinary spectrum of gases is discontinuous, consisting of isolated bright lines, whose position is characteristic of particular substances; while incandescent solids or liquids, or gases in a state of extreme condensation, afford a continuous spectrum (which may, however, be interrupted by dark lines if the light passes through an absorptive medium). The sun and the stars show by their continuous spectra that their light proceeds from incandescent solids or liquids or from gases extremely condensed. In the case of the sun, it is believed that its light comes from a stratum of luminous cloud in its atmosphere. The spectrum of some of the nebulæ shows the bright lines which are characteristic of a diffused gas. The spectroscope has therefore reinstated in more than its original force the argument of Herschel. We may with confidence regard the nebulæ which show the characteristic gaseous spectrum as bodies of matter in some such condition as that assumed by the nebular theory to have been the initial condition of the solar system.*

* The nebular theory has been recently subjected to a searching criticism by T. C. Chamberlin, in *The Journal of Geology*, vol. v, p. 653, vol. viii, p. 58, and vol. ix, p. 369; and by F. R. Moulton, in *The Astrophysical Journal*, vol. xi, p. 103. It seems not improbable that arguments apparently so cogent as are presented in these able articles will lead to a somewhat radical modification of the prevailing views in regard to the genesis of the planetary system. While these writers believe the theory of Laplace to be untenable, they still hold to the probable origin of the planetary system from a nebula. There is little doubt that *a* nebular theory will prove true even if *the* nebular theory of Laplace is abandoned.

EVOLUTION IN GEOLOGY*

We must next consider the development of the idea of evolution in geology. We have seen that the geologists at the beginning of the nineteenth century were all catastrophists.† Hutton, who did more than any other man of his time to establish geological theorizing upon a sound foundation, understood well how continents are progressively degraded by the action of the atmosphere and water; but he knew of no intelligible process for the elevation of continents, and was therefore obliged to postulate the occasional occurrence of inexplicable catastrophes, in which continents were suddenly and violently elevated, to undergo gradual degradation thereafter by atmospheric and aqueous agencies. In like manner, the paleontologists of the early part of the nineteenth century all believed that the history of life upon the globe had been a history of successive creations. Again and again some violent cataclysm had exterminated all the life of the globe; and again and again creative power had originated, by means which science could not hope to formulate or explain, a new fauna and flora.

To Sir Charles Lyell, more than to any other one man, belongs the credit of delivering geological science from the vagaries of catastrophism. The first edition of Lyell's classical and epoch-making work, "The Principles of Geology," was published in 1830. A new edition of that book was issued every few years, almost

* See references in note on page 41.

† Page 51.

until the time of the author's death in 1875, so that for a period of more than forty years the successive editions of that book afford a history of the progress of geological science. In the seventh edition of "The Principles of Geology," published in 1847, and in all later editions, one chapter bears the title, "Uniformity in the Series of Past Changes in the Animate and Inanimate World." In that chapter was presented in definite form the argument, of which, indeed, the whole book was an expansion, against the necessity of the supposed catastrophes of the older geological school. In the repudiation of catastrophism, Lyell rendered the Huttonian doctrine consistent. The merit of Hutton was in his fundamental principle that the past changes of the globe are to be interpreted in the light of the changes now going on. His belief in catastrophism was therefore obviously incongruous with the general spirit and tenor of his theorizing. In Lyell, then, for the first time, we find a consistent development of the Huttonian doctrine. Lyell called attention to the fact that the earth's crust is in continual oscillation at the present time. Some coasts, like that of Scandinavia, are slowly rising; others, like that of Greenland, are sinking. We only need to suppose that similar changes have been going on through indefinite ages of the past in order to account for any amount of change in level which may be required. There is no need, then, of assuming the occurrence of inexplicable catastrophes in order to account for the elevation of continents. A continuous gradual elevation of a part of the crust of

the globe would produce a continent if only continued for a sufficient time. Lyell, again, gave for the first time the true interpretation of the abrupt changes in flora and fauna between successive geological formations. As was pointed out when we were discussing the catastrophism of the early geologists,* the most abrupt changes in flora and fauna usually occur where the underlying and the overlying series of strata are manifestly unconformable with each other. Lyell showed that the inference to be drawn in such cases was, not that there had been a universal extermination of life, followed by the creation of a new fauna and flora, but rather that there was an unrecorded interval of time, in which species may have migrated from one district to another, old species one by one may have become extinct, and new species one by one may have been introduced. The lack of geological record of such an interval of time would make the result of a change which had really been gradual appear sudden and catastrophic.

But, while geology owes so much to Lyell and to the uniformitarian school of which he was the founder, the doctrines of that school are by no means held in their completeness by geologists of the present time. The great merit of Lyell was the unshrinking consistency with which he insisted that no forces or agencies must be postulated in geological theorizing which cannot be shown to be in action at the present time. The past must be interpreted purely in the light of the pres-

* Page 52.

ent. But much of Lyell's thinking was vitiated by a latent assumption that uniformity of law from age to age involves uniformity in phenomena. Of course Lyell would never have acknowledged that he held a doctrine so absurd. When distinctly formulated, the assertion that uniformity of law means uniformity in phenomena from age to age, is almost self-contradictory. It is, in reality, as a consequence of the uniformity of law and the constancy in the action of physical forces, that the earth has come to its present condition from a past condition different from the present, and tends to a future condition different from either the present or the past. If, for instance, the earth is to-day a relatively hot body surrounded by cold space, the assumption that physical forces are constant and that their laws are uniform compels us to believe that the earth was once hotter than it is, and that it is destined to be colder than it is. But the thinking even of great men is often perverted by some false conception, whose falsity might be perceived if it were distinctly formulated, but which in latent and unrecognized condition serves to influence their conclusions. Lyell's dogma of uniformitarianism made him unwilling to admit within the scope of geological science a conception of a condition of the earth very different from the present. He insisted, as Hutton had insisted in the previous century, that geology has nothing to do with cosmogony. To Lyell, as to Hutton, geological phenomena gave no indication either of beginning or ending of the earth. Even in the latest edition of his "Principles of

Geology," the title "Nebular Theory" does not appear in the index. In Lyell's earlier editions, he called attention to the fact that recent paleontological discoveries are continually carrying back the existence of some particular group of animals or plants to an earlier geological period than that in which they had been previously known to occur, and accordingly insinuated a doubt whether there has been any real progress in the development of life since Cambrian time. Since most geological processes are obviously very slow, Lyell assumed that all geological processes must be slow, and accordingly conceived of geological time as almost an eternity. In the continuous oscillation of the earth's crust, Lyell assumed that elevations and subsidences of various areas followed each other with kaleidoscopic indefiniteness, so that continent and ocean may have repeatedly exchanged places in the course of geological time. This phase of the Lyellian doctrine finds beautiful expression in the lines of Tennyson,—

> "There rolls the deep where grew the tree.
> O earth! what changes hast thou seen!
> There, where the long street roars, hath been
> The stillness of the central sea."

Huxley has shown that the evolutionary school of geology, which is dominant to-day, is the heir both of catastrophism and of uniformitarianism.* The one of those extreme views is about as dead as the other. From the uniformitarianism of Lyell, modern geology inherits a consistent and unflinching faith in the doc-

* *Geological Reform*, in *Discourses Geological and Biological*, p. 305.

trine that laws and forces which are illustrated in the changes now in progress, and those alone, must be appealed to for the explanation of the changes which went on in the past. But modern geology fully accepts the truth that uniformity of law not only does not contradict, but does absolutely require, the recognition of vast changes in phenomena. Modern geology does not hesitate to recognize the earth as a cooling globe, and to find in its contraction, with progressive cooling, the explanation of crustal movements and of the origin of the earth's physical features. Modern geology does not hesitate to say that the earth as a habitable globe must run its course in a distinctly finite period of time—a period, indeed, measured by tens or at most by hundreds of millions of years. The evidences of beginning and ending of the present phase of the history of the earth are unmistakable. Modern geology does not hesitate to link itself with astronomy through the nebular theory, and to find in the conception of Laplace, or some modification of that conception, the explanation of the origin of the earth. Modern geology recognizes that, although the majority of geological changes are slow, some geological changes are rapid. Intermittent effects may follow the action of a continuous force. The rigidity of rock masses may resist for a long time an accumulating pressure, and the yielding may take place at last with comparative rapidity. Hence it is probable that the physical history of the globe has been an alternation of periods of comparative crustal stability, with periods of compara-

tively rapid crustal movement in which great mountain ranges have been elevated. Some geological movements, indeed, may have been relatively so rapid as, in a qualified sense, to deserve the name of catastrophes. Modern geology holds, as Dana taught more than half a century ago, that the fundamental differentiation of the earth's surface—the distinction of continent and ocean—dates from a very early stage in the process of the earth's refrigeration. Although the continents have been in the past largely covered by shallow seas, it does not appear that they have ever formed the bed of deep oceans, or that there has been anything like a general exchange of position between continent and ocean. And surely no geologist of the present day would have a shadow of doubt that life commenced in pre-Cambrian time with comparatively low and simple forms, and that the progress through the ages has been marked by the successive appearance of higher and higher types, and by an expansion of animal and vegetable life to a continually increasing richness of diversification.

EVOLUTION IN BIOLOGY

*The Origin of Species**

We come now to the discussion of the most important subject of scientific investigation in the half-century just closed—evolution in biology, or, more particularly, the question of the evolutionary origin of the

* An admirable historical sketch of evolutionary thought prior to Darwin may be found in Osborn, *From the Greeks to Darwin*. Darwin, *Origin of*

species of plants and animals. The beginning of the modern phase of the question of evolution in biology was in the year 1858. But, before referring to the papers whose promulgation in that year inaugurated the new era in biological science, it is well for us to notice the preparation which had been made previously to that time for the development of a theory of evolution in biology. Before the year 1858, evolutionary theories in astronomy and geology had come to be generally accepted. It was the almost unanimous belief of astronomers that some form of the nebular theory must be accepted as the explanation of the origin of the planets. The catastrophism of the early geologists had received its death-blow from the arguments of Lyell. It had come to be recognized by every one that the whole history of the inorganic arrangements of the earth, from the initial condition of the nebula to the present time—the origination of the globe itself, and the development of oceans, continents, mountains, and all other physical features,—was the result of a perfectly continuous evolutionary process. The fact that evolution had ruled with consistent sway in all the

---

Species, is still the classical work on the general subject of evolution of species and on the theory of natural selection. It is supplemented, not superseded, by later writings. A few of the other most important works on evolution in general and on natural selection are: Wallace, *Contributions to the Theory of Natural Selection*; Wallace, *Darwinism*; Huxley, *Darwiniana* (*Collected Essays*, vol. ii); Gray, *Darwiniana*; Romanes, *Darwin and After Darwin*, vol. i, *The Darwinian Theory*; Conn, *Evolution of To-day*; Le Conte, *Evolution and its Relation to Religious Thought*; Drummond, *Ascent of Man*; Marshall, *Lectures on the Darwinian Theory*. Other works bearing on special phases of the doctrine of evolution will be cited later. The views expressed in the present work are for the most part the same as were briefly outlined in the article on *Evolution* in Sanford's *Concise Cyclopedia of Religious Knowledge* (republished with some modification in my *Twenty-Five Years of Scientific Progress, and Other Essays*).

inorganic arrangements of the earth, could not fail to suggest doubts of the prevalent belief that the history of organic nature was a history of a discontinuous succession of special creations.

We must notice, too, that in a special sense the views which Lyell had rendered popular in historical geology prepared the way for organic evolution. Cataclysmic periods of universal extermination of life, which figured in the theories of the older geologists, had been universally abandoned. Everywhere it had come to be recognized that species appeared and disappeared, one at a time or a few at a time, not by the simultaneous destruction and creation of entire floras and faunas. Before the year 1858, even the most conservative geologists were ready to concede that there is no satisfactory evidence of an epoch of universal destruction of life and simultaneous creation of a new fauna and flora at any stage of the earth's history. The universal acceptance of a belief that the progress of life, from the Cambrian era to the present, had thus been a gradual progress, and not a progress marked by a series of catastrophic exterminations and new creations, naturally suggested the idea that the progress of life was a strictly continuous process—an evolution.

In the middle of the nineteenth century, then, the world was ready for a more favorable consideration of the hypothesis of biological evolution than that hypothesis had ever received before. Of course the question had been raised again and again in the past. Everyone who knows anything of animal and vege-

table life knows that the life of every individual is most typically an example of continuous evolution. Every individual has its origin in a condition of unicellular simplicity, and gradually attains to the complexity of structure and variety of function which characterizes the adult. The question must always have been ready to suggest itself to the philosophic mind, whether the origin of the earliest individuals of a species was not, like the origin of all their successors, due to a process of evolution. In vague and crude forms the idea of evolution of one type of life from another and lower type was taught by many of the Greek philosophers; and in the beginning of the nineteenth century (1801) the French naturalist, Lamarck, presented the idea of evolution of new species in a form which may fairly be considered a scientific theory.

Lamarck's views, however, made little impression upon the thought of his time. The reason was threefold. First, he was unable to give any satisfactory explanation of the method of evolution. He recognized some of those relations between different species of animals and plants which we have now learned to interpret as evidences of the origin of species by descent with modification. But his explanation of the method of evolution was certainly inadequate; and, as we shall see hereafter,* it is not certain that it has any degree of validity. Secondly, the time was not ripe for a theory of evolution. The general state of the world's thought in 1801 was very different from what it was in 1858.

---

* Page 214.

In the interval between those two dates, the acceptance of evolution in astronomy and geology had prepared the way for the acceptance of an analogous belief in biology. The complete abandonment of the notion of universal exterminations followed by new creations had removed one of the most serious difficulties in the way of biological evolution. Thirdly, Lamarck was unfortunate in that he found an opponent greatly his superior in knowledge and ability. Georges Cuvier, the great anatomist and paleontologist, appeared as the champion of the special creation of every species, and won an easy victory over the crude and premature hypothesis of Lamarck. Though on the question of evolution we now count Lamarck right and Cuvier wrong, Cuvier is nevertheless recognized as worthy of far higher honor than Lamarck for his aggregate of service to scientific truth. The instances are not few in the history of science in which, as in this case, the influence of a name deservedly honored has served to maintain for a time an erroneous belief. We have already had occasion to note the influence of Newton in delaying the acceptance of the views of Huyghens in regard to the nature of light.*

The beginning of the modern phase of the history of biological evolution was in 1858, when Alfred Russell Wallace, who had been spending four years in the Malay Archipelago in the study of the zoology, botany, and geology of that region, sent to his friend, Charles Darwin, an essay "On the Tendency of Varieties to

* Page 129.

depart indefinitely from the Original Type."* It was with strangely mingled feelings that Darwin read his friend's essay. He had been at work himself for twenty years on a theory of evolution. Fourteen years before, he had written a preliminary statement of his views, and shown it to one of his scientific friends.† He had waited those many years to gather additional facts, to answer the objections that had arisen in the progress of his thinking, to work out many points more in detail, and in general to prepare himself eventually to publish his views in more complete form and with more conclusive evidence. It was, indeed, startling to find the central idea of his own work formulated in Wallace's paper. With a generosity of which few men would have been capable, he was disposed at first to publish his friend's essay, and still withhold his own work from publication. But two of his friends, Lyell, the geologist, and Hooker, the botanist, felt that such self-abnegation would be unreasonable; and it was finally arranged that at the same meeting of the Linnean Society should be read Wallace's essay, and a paper by Darwin consisting of extracts from the sketch written in 1844 and a part of a letter to Asa Gray writen in 1857. The two papers presented at the Linnean Society that memorable evening are the Wittenberg Theses of the intellectual reformation of our time. In the following year was published Darwin's epoch-making book on "The Origin of Species by means of

---

* Included in *Contributions to the Theory of Natural Selection.*
† Sir Joseph Dalton Hooker.

Natural Selection, or the Preservation of Favored Races in the Struggle for Life." With the publication of that book, the discussion emerged from the associations of technical students of science into the larger arena of the world's thought.

It is impossible to praise too highly the conduct of these two illustrious men in their relation to each other. It afforded a beautiful contrast to the petty squabbles about priority which have so often disgraced the lives even of eminent scientific men. It was a fine example of the fulfillment of St. Paul's precept, "in honor preferring one another." Wallace's treatment of Darwin was a worthy reciprocation of Darwin's own generosity. At the meeting of the British Association in 1867, he publicly declared that he was proud to be a Darwinian; and, in the preface to his "Contributions to the Theory of Natural Selection," he said, "I have felt the most sincere satisfaction that Mr. Darwin had been at work long before me, and that it was not left for me to attempt to write 'The Origin of Species.' "

Before considering the theory of natural selection, we must notice two comprehensive laws in the realm of life with which the theory stands in intimate relation. Those two laws are heredity and variation. We may state those principles in a simple, though somewhat paradoxical, form in two propositions:—(1) The offspring is always like its parent. (2) The offspring is never like its parent.

The offspring is always like its parent. It inherits from its parents those qualities which mark it as an in-

dividual of a particular species. The offspring of a cat is never anything but a kitten. The plant that grows from an acorn is never anything but an oak. But, as every one knows, the offspring inherits from its parents far more than those characteristics which mark it as an individual of a particular species. We know well, in the case of ourselves, that we have inherited from our parents far more than those characters which belong to us all as human beings. We have inherited from our parents peculiarities of size, form, complexion, color of hair, susceptibility, it may be, to particular diseases, peculiar mental and moral traits. Analogous facts we observe continually among our acquaintances. The same thing is noticed by all who attentively study domestic animals of any species. If the facts are less familiar to us in regard to wild animals and in regard to plants in general, it is chiefly because we do not give so much attention to individual peculiarities in the case of wild animals and plants as in the case of human beings and domestic animals, though it is doubtless true that in general the amount of variability is greater in domestic animals than in wild species.

It is equally certain that the offspring is never exactly like the parent. No human being shows an exact repetition of the characteristics of father or mother. No two children in the same family, no two kittens in the same litter, are exactly alike. No two seeds in the same pod are exactly alike, nor will they develop into plants exactly alike. Every individual exhibits more or less of individual peculiarity.

We may say, then, that the orbit of every species of animal or plant is determined by the centripetal and centrifugal forces of heredity and variation. Whether we can or cannot give an explanation of these laws, we must recognize their existence throughout the realm of life, and a theory of evolution must be based upon them.

If one species is transmuted into another species, it must obviously be by one of two processes or by some combination of the two. Either there must be from time to time very great variations, so that in these exceptional cases the offspring is so different from the parents as to be marked at once as the beginning of a new and distinct race; or, secondly, there must be from generation to generation a progressive accumulation of small variations tending in one direction; or, thirdly, there must be the occurrence of both these conditions. But here we meet with what has always been felt as the great difficulty in the way of the evolution of species. Within the limited time in which accurate observations of living beings have been made, the general result of our observation is that variation is small in amount, and, instead of being cumulative from generation to generation, it simply oscillates around an average type. A simple illustration will make clear the state of the case. In the human species variations in stature are continually occurring. Yet, with the exception of cases more or less decidedly pathological, those variations in stature are confined within narrow limits; and there seems no tendency for the variation to

be cumulative in successive generations. We do not observe that the children of small men are smaller than their parents, and their grandchildren smaller still, so as to show a tendency to the development of a pygmy race; nor do we find a tendency to cumulative variation in the other direction, so as to develop a race of giants. The same thing might be illustrated by any other variable characteristic in the human species, or in any other species with which we are well acquainted. A certain average character of the species maintains itself substantially invariable from generation to generation. Some individuals are larger and some are smaller; some individuals lighter colored and others darker. But the variations in these and in other characters simply oscillate around the average type. It is obvious that, so long as this state of things continues, there can be no such thing as the evolution of a new species.

But it would be a tremendous logical saltus, from the fact that, within the narrow limits of our observation, variation appears to be small in amount and merely oscillatory, to leap to the conclusion that the same has been true throughout the world and throughout the lapse of geological time. Accurate observation upon the characters of any organic species has been extended over only a few centuries at the utmost, and the period covered by that observation is a period in which the physical environment has been comparatively stable. No great geographic or climatic changes have been in progress upon the surface of the globe during the time

in which zoologists and botanists have been at work. It must be recognized as possible, and not very improbable *a priori,* that, in the changing environment to which animals and plants have been exposed in the lapse of geological time, with its immense vicissitudes of climate and geography, there may have been times when variation has been cumulative in particular directions, instead of being merely oscillatory. The theory of evolution, however, would not have a very satisfactory foundation if it rested only on such an *a priori* possibility. To give satisfactory ground for a belief in evolution, it must be shown that there is some agency at work in nature which would tend, under certain conditions, to make variation progressive. It is precisely that need of the doctrine of evolution which is supplied by the theory of natural selection, as proposed by Darwin and Wallace.

The theory of natural selection is founded upon three unquestionable truths in regard to the realm of life. Two of them have been already mentioned as underlying any speculation in regard to evolution. These are the laws of heredity and variation. The third general law of organic nature on which the theory of natural selection rests, is the tendency of every species of animal or plant to multiply in geometrical ratio. Just at the close of the eighteenth century, the essay of Malthus on the "Principle of Population" called the attention of economists and sociologists to the tendency to geometrical increase in the human species. The same law operates in the case of every

species of animal or plant, without any of the prudential restraints which modify its action in the case of man. Even in the case of creatures which breed most slowly the law holds good. The elephant, for example, produces young only about once in ten years, and generally only one at a birth. Yet, if there were no check upon the multiplication of that species, there would be in a few generations more elephants than could find standing-room upon the earth, to say nothing of the impossibility of their finding means of subsistence. Darwin estimates that the progeny of a single pair of elephants, after the lapse of seven hundred and fifty years, would number about nineteen million. And, when we come to consider some of the lower forms of animal and vegetable life, which produce eggs or spores by the million, the significance of the law of geometrical increase becomes startlingly impressive.

The actual fulfillment of this tendency to geometrical increase is prevented by the fact that every individual is exposed to a continual succession of perils from the earliest moment of its existence until it finally succumbs in death. By far the greater number of the germs of life which are produced never get beyond the germinal stage. The vast majority of eggs are devoured or otherwise destroyed before they are hatched, and the vast majority of seeds before they germinate. But, if the egg is hatched or the seed germinates, and the independent life of the new animal or plant begins, the individual is exposed to a continuous series of perils along the whole course of its existence. These

dangers to the life of each individual come in part from inorganic conditions, such as the inclemency of weather, the extremes of heat and cold, of drouth and damp. They come in part from the presence of rivals destined to live upon the same kind of food; and multitudes are starved in the relentless competition. Multitudes, again, of plants and animals are devoured by animals for which they constitute the appropriate food. If an individual survives to maturity, it does so in virtue of having successfully run the gauntlet of these perils, and having overcome in what Darwin has vividly and almost poetically called, "the struggle for life."

But now, since variation is universal, and no two individuals of any species are exactly alike, it is obvious that some individuals in every generation will be better adapted than others to conquer in the struggle for life. They may be protected against external cold by a warmer coat of fur or feathers; they may be able by greater strength or greater cunning to secure food, where their weaker or less cunning brethren starve; they may be able, in time of scarcity of the best quality of food, to digest an inferior quality of food and thrive upon it, while other individuals of the species may not be able to use the inferior food without great impairment of vitality; they may escape from carnivorous animals by greater swiftness, or be able to repel their attacks by greater strength and courage. If in any way whatever some of the individuals of a species are better adapted for success

in the struggle for life, those individuals will be likely to survive to maturity, and may therefore have the opportunity to propagate their species. They will be *naturally selected* to breed the coming generation. By the law of heredity it will naturally follow that their offspring will inherit, in greater or less degree, those favorable peculiarities which have given the parents victory in the struggle for life. This, then, is the principle of natural selection.

The phrase, "natural selection," is, of course, a metaphorical one. It was suggested to Darwin by the experience of cultivators of plants and breeders of animals. No breeder of intelligence and skill will allow all his animals indiscriminately to propagate. If he only desires, in general, to maintain a healthy and vigorous stock, he will select for breeding purposes those of his animals which appear to be in the best general condition. If, on the other hand, he desires to develop any particular quality, he will select for breeding the individuals which already possess that quality in highest degree. If, for instance, the cattle-breeder desires to raise a race of cattle characterized by a tendency to take on flesh and develop great weight—a quality which would be profitable for the production of beef—he will accomplish that result by continually selecting his heaviest bulls and cows for breeding. If he wishes to improve his herd with reference to dairy products, he will select for breeding those cows which yield milk in largest quantity, or milk of richest quality, according as he proposes to sell milk

or butter. If he desires, as a matter of fancy, a breed possessed of any peculiarity of appearance, as extreme length of horns or extreme shortness of horns, he will select his animals for breeding in reference to the particular qualities which he wishes to develop. The same sort of selection is practiced by agriculturists and horticulturists in the endeavor to produce choice varieties of the plants cultivated for their beauty or for their economic uses. In every case the principle upon which successful breeding depends is the careful selection of the most promising individuals from which to breed. This artificial selection, then, as practiced by cultivators and breeders, suggested the metaphorical phrase, "natural selection." There is, of course, an obvious difference between the artificial selection practiced by the breeder, and natural selection. Artificial selection is based upon qualities which are useful, not to the animal or plant itself, but to its owner. Those qualities may be even detrimental to the vitality of the animal or plant. Natural selection is obviously related to the qualities which favor the life of the individual or the propagation of the race.

That natural selection expresses a principle actually existing in nature can scarcely be doubted. It rests upon no hypothetical foundation. The laws of heredity and variation and the tendency to geometrical increase are unquestionable truths, and the principle of natural selection seems to be an inevitable corollary from them. The theory has a charm for the philosophic mind in its wonderful simplicity. In that char-

acteristic it reminds one of Newton's theory of universal gravitation.

It should further be noticed that natural selection is exactly adapted to the explanation of the process of evolution of living beings, in that it accounts at once for long periods of stability and for periods of comparatively rapid change. In other words, natural selection is at times a conservative and at other times a progressive force. Let us suppose that a species has become, no matter how, substantially adapted to its environment. Its size, form, color, instincts, habits, mode of reproduction, are all so completely adapted to its environment that it just fits the place in the polity of nature in which it finds itself. In that condition the effect of natural selection must be conservative; for, since the species has become substantially adapted to its environment, any considerable change will be likely to be injurious. Natural selection will therefore stamp out all variations that diverge widely from the parent stock, and will tend to keep the race, generation after generation, true to its specific character. But now let us make a simple supposition, such as, according to geological evidence, has been realized again and again in the past. Let us suppose that a certain portion of the earth's crust experiences a movement of elevation, with the result of converting an archipelago into a continuous area of continental land. Consider how far-reaching must be the effects of such a geographical change. First of all, in the immediate locality of the upheaval, an area of sea is converted into land, and

this necessitates a migration of the aquatic animals. Secondly, the crustal movement will produce greater or less climatic change. Elevation of land produces directly a lowering of temperature, amounting, on the average, to about one degree Fahrenheit for every three hundred feet of elevation. But the indirect effects of such an elevation may be very much greater than the direct effects. The change of sea into land may change the direction of ocean currents, which exert a most potent influence in the transfer of heat from lower to higher latitudes and in the transfer of cold from higher to lower latitudes. If the movement is not purely local, but is a part of a general movement of continental emergence, attended by a general diminution in the areas of shallow sea adjoining the continents, there will be a tendency, as has been shown by Chamberlin in his interesting discussion of the causes of the Glacial period, to make a colder climate all over the globe, by diminishing the amount of carbon dioxide in the atmosphere.* Thirdly, the changing of a group of islands into a continuous area of continental land will give opportunity for species that had been confined to particular islands to extend their range by active or passive migration throughout the territory which is now continuous. In this way many species will be brought into competition with new rivals, or exposed to attacks of new enemies. Many species will be compelled to live upon different kinds of food, and to make

* See page 73.

other changes in their habits. It is not too much to say that so simple a change as the supposed crustal elevation will throw almost every species of plant or animal that had previously lived on the land or in the shallow seas of the territory in question more or less out of harmony with its environment. Under these conditions, natural selection will cease to be a conservative force, and will become a progressive force. The average character of each species in the area being no longer adapted to its environment, variations in certain directions will give to their possessors an advantage in the struggle for life; and individuals thus varying will now be selected to survive to maturity, instead of those that keep most nearly true to the average character of the species in former generations.

If it be true that the various species of animals and plants have arisen by a gradual process of evolution, we ought to find indications thereof in the relations existing between different species and in the relations of organisms to time and space. The limits of this discussion will allow us to do little more than to give a sort of inventory of the indications of evolution—the growth-marks—that may be recognized in the present condition of plants and animals. For fuller illustration of the subject reference may be made to the books in which the argument in favor of evolution is presented more fully. Or perhaps one might better say, for fuller illustration of those relations of plants and animals that are suggestive of evolution, the student may refer to any modern book on any department of

natural history; for no one can appreciatively study zoology or botany, comparative anatomy or embryology, geographical distribution or paleontology, without finding everywhere illustrations of evolution.

One of these marks of growth is seen in the preservation of homology of structure in organs appropriated to widely different uses. A classical example of this sort is seen in the structure of the limbs of vertebrates. The arm of a man, the fore leg of an ordinary mammalian or reptilian quadruped, the wing of a bird, a bat, or a pterodactyl, the flipper of a whale—are all constructed on the same plan. The pectoral fins of fishes are conformed to the same plan in its general outline, though with much greater differences in the details. Now such a relation is perfectly intelligible, if all these animals have had a common ancestry, and all have inherited from that common ancestry a common type of structure, which has never been lost, but which has been more or less modified in adaptation to varying conditions and varying modes of life. It is not, however, easy to see why those organs should all have the same plan of structure if each one has been created independently of any relation to any of the others. The teleological suggestion that that plan of structure is maintained in all these organs because it is the only plan, or at least the best plan, for organs appropriated to all those different functions, is obviously inadmissible, since we find in other branches of the animal kingdom organs for every one of these functions—organs for prehension, for walking, for flying, and for

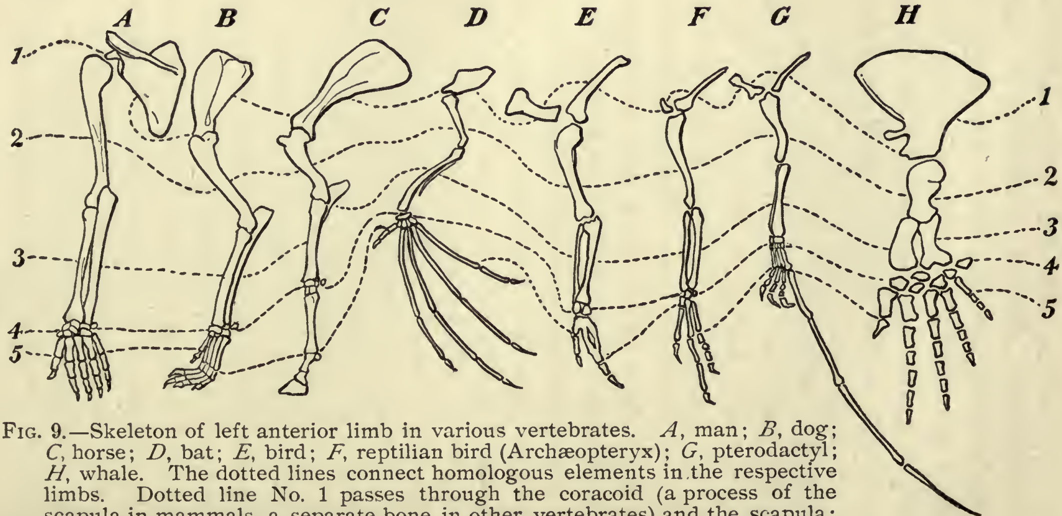

FIG. 9.—Skeleton of left anterior limb in various vertebrates. *A*, man; *B*, dog; *C*, horse; *D*, bat; *E*, bird; *F*, reptilian bird (Archæopteryx); *G*, pterodactyl; *H*, whale. The dotted lines connect homologous elements in the respective limbs. Dotted line No. 1 passes through the coracoid (a process of the scapula in mammals, a separate bone in other vertebrates) and the scapula; No. 2, through the humerus; No. 3, through the radius and the ulna; No. 4, through the carpus; No. 5, between the metacarpals and the phalanges. Mainly taken (with modifications) from Le Conte's "Evolution and its Relation to Religious Thought."

swimming—constructed on plans which present no resemblance whatever to the plan of vertebrate limbs. The invalidity of the teleological explanation appears yet more manifest when we notice that the degrees of resemblance in structure between the various forms of limbs that have been referred to are by no means proportional to the degrees of resemblance in function. The function of a bat's wing is essentially the same as that of a bird's wing, yet the bat's wing has a very close resemblance in structure to the arm of a man or the fore leg of a dog, while its resemblance in structure to the wing of a bird is very much less close. In like manner, the function of the whale's flipper is obviously much more similar to the fish's fin than to the man's arm or the dog's leg, yet the flipper of the whale structurally resembles the fish's fin only in the broadest and most general outlines of its plan, while its resemblance to the arm of a man or the leg of a dog is far more close and detailed. The inference is an irresistible one that the structure of these various organs has not been determined primarily by the teleological conditions, but by something entirely different.

An argument of the same sort, but, if possible, even more conclusive, is drawn from rudimentary organs. By rudimentary organs we mean organs which in particular species are apparently destitute of function. In these species the organs in question are generally very small and more or less imperfect in structure, whereas in other species more or less closely allied the corresponding organs are of full size and complete develop-

ment, and perform their normal functions. Rudimentary organs are by no means a rarity in organic nature, being found in almost every group of animals and plants and in almost every part of the organism. A single example will illustrate at once the meaning of rudimentary organs and their bearing upon the question of evolution. In ordinary beetles the posterior wings are used for flying, while the anterior wings are thickened and hardened, and serve only as protective covers beneath which the posterior wings are folded away when at rest. There are, however, many beetles which are destitute of the power of flight. In some of these we may find a pair of little posterior wings concealed under the wing covers, which are soldered together along the middle of the back, so that the covers can never be opened, and the wings can never be spread. On the theory of evolution, the presence of these unused posterior wings is perfectly intelligible. The beetles that possess them, though now destitute of the power of flight, are the modified descendants of other beetles that did fly; and, though they have ceased to spread their wings, they still possess wings of small size, which they have inherited from their flying ancestors. Apart from the idea of evolution, the only conceivable explanation of such useless organs would be in some sort of Platonic conception of an archetype in the Creative Mind, according to which all beetles were created. But, if any one finds satisfaction in the thought that the Creator was pleased to fashion all beetles according to a coleopterous archetype, and that

the possession of posterior wings was a part of the character of that archetype, his satisfaction will soon be disturbed by learning that there are other flightless beetles which are entirely destitute of wings. Evidently, then, the Creator has not been pleased to create all flightless beetles with wings according to the coleopterous archetype, but only some of them. The theory of evolution gives a satisfactory explanation both of the presence of wings in some flightless beetles and of their absence in others. We have only to suppose that different families or genera of beetles at different times have so changed their habits as to abandon the exercise of flight. Those groups of beetles in which that change has been a comparatively recent one, still retain wings in a more or less reduced condition; but those groups of beetles in which the disuse of the power of flight has continued for a much longer series of generations, have completely lost the wings. The presence of a rudimentary organ marks an intermediate stage between the complete and functional development of the organ and its total loss.

Other indications of genetic relationship between different species are furnished by the facts of embryology. All animals above the unicellular protozoa commence life in the condition of a single cell, the ovum, which is obviously a condition essentially similar to the permanent condition of the protozoa. Somewhat later, in the development of the multicellular animals, appears what has been called the gastrula stage, which appears to be, though with much variation in

detail, essentially the same thing in all. The gastrula, when most typically developed, is a sac formed of two layers of cells, the outer and the inner layer being more or less distinctly differentiated from each other. It is a very noteworthy fact that these two layers of cells which form the gastrula have respectively the

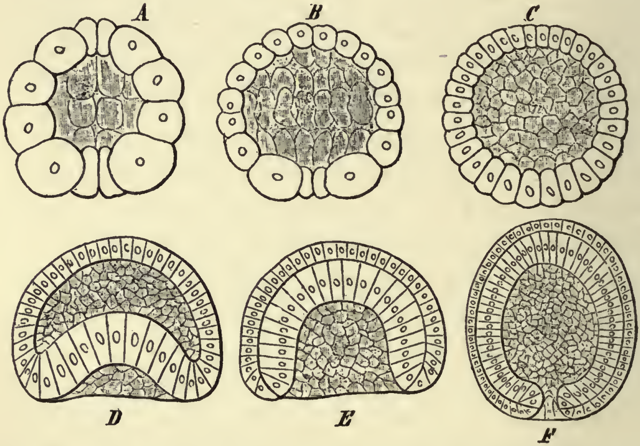

Fig. 10.—Six stages in the development of the gastrula in Amphioxus (a very low type of vertebrate). From Gegenbaur's "Vergleichende Anatomie der Wirbelthiere."

same destination in all animals. The outer layer always forms the epidermis, and, in those animals which have a well differentiated nervous system, it forms also the nervous centers and the essential parts of the sense organs. While the tissues derived from the outer layer of the gastrula are uniformly the ones which are in relation to the external world, the internal layer of the gastrula develops with equal constancy the

epithelial lining of the alimentary canal and its appendages. In some of the lower multicellular animals, as, for instance, the cœlentera, the adult development passes little beyond the gastrula stage. The adult body consists of a double-walled sac, whose single cavity is essentially a digestive cavity, and whose wall exhibits but slight development of any tissues between the integument and the lining of the digestive cavity. In the higher animals, however, a great variety of tissues come to be developed between the epidermis and the alimentary mucous membrane. But, however great the complexity of these intermediate tissues, the destiny of the primitive layers of the gastrula remains essentially the same. This similarity in the early stages of development, and this essential homology of the epidermis and of the epithelium of the alimentary canal in all multicellular animals, are profoundly suggestive of a unity of origin for the whole animal kingdom.

Not only do we find in the very earliest stages of development an essential unity pervading the whole animal kingdom, but, in later stages of development, we find a very general law that immature conditions of the higher or more specialized animals exhibit greater or less resemblance to lower or less specialized animals more or less closely allied to them. A larval crab (brachyuran) has a long jointed tail (abdomen) like that of a lobster (macruran); but, in its later development, other parts of the body increase in size out of all proportion to the tail, which thus becomes the

insignificant rudiment which characterizes the adult crab. At a certain stage in the development of man, or any other mammal, the heart is a two-chambered organ like that of a fish, and the aorta passing forward from the heart divides right and left into a series of branches like the branchial arches of a fish. Some of these arches of the aorta become obliterated in the subsequent process of development. Others are converted into the main arterial trunks of the systemic and pulmonary circulation. In the same stage of the embryo in which the aortic arches may be seen branching right and left from the main stem of the aorta, the cavity of the pharynx extends itself on each side into a series of pouches, which nearly meet a corresponding series of depressions on the sides of the neck. In fishes these pouches open externally, the openings being the gill slits which are so conspicuous in the neck of a shark. It has been commonly asserted that such perforations are formed in the embryos of all vertebrates; but more recent studies seem to indicate that, in the mammalian embryo, at the stage of fullest development of the pharyngeal pouches, a thin membrane separates each pouch from the corresponding external depression. It is, however, none the less obvious that these pouches and the corresponding external depressions are homologous with the gill pouches and gill slits of a shark. In the adult mammal these structures are obliterated, with the exception of one on each side. In the case of that one, the pharyngeal pouch becomes the Eustachian tube, the external depression becomes the external

Fig. 11.—Three successive stages of embryos in four classes of vertebrates. *A*, shark; *B*, salamander; *C*, chick; *D*, man. The formation of gill slits is seen in the earliest stage of all alike; but the slits are seen to persist in the fish, and to disappear in the others. From Romanes' "Darwin and After Darwin."

auditory meatus, and the membrane between them (with some modification) becomes the tympanic membrane.

If we were converting a Roman trireme into a steamboat, we should find it convenient to plug up most of the oar-holes, though it might be advantageous to keep some of them for use as port-holes; but, if we were building a steamboat *de novo,* it would be an absurd procedure to bore a series of holes almost through its sides, simply that we might have the opportunity to plug them up.*

The law that immature stages of higher or more specialized organisms tend to resemble the adult forms of lower or less specialized organisms, is of very wide application. In many cases, however, the law fails to be exemplified by reason of adaptive modifications in the larval stages. The developing organism must possess at every stage a structure adapted to the conditions of life in which it is placed; otherwise it could not live. It is often the case that the conditions of life to which immature and larval forms are subject, are entirely different from those under which the adults will live, and equally different from the conditions in which lived those lower or less specialized creatures which are supposed to have been their ancestors. Under these conditions, structures are developed in the larva which have no relation to their ancestry, but are determined solely by their present conditions of life.

The parallelism that may often be traced between

---

*Conn, *Evolution of To-day*, p. 132.

a series of organisms in the order of systemic rank and a series of embryonic and larval stages in the development of the highest and most specialized forms, derives additional significance for the evolutionist when we can recognize a third series parallel to these two, namely, the series of forms in successive geological periods. Many illustrations might be given of this triple parallelism—the parallelism of embryonic development, systemic rank, and geological succession. That we do not find such a triple parallelism universally exhibited is easily explained; on the one hand, by the adaptive modifications of larval and immature forms to which reference has just been made, and, on the other, by the imperfection of our knowledge of extinct forms of life.

In very many respects the order of succession of species in geological time is what we should naturally expect on the theory of evolution.* The most conspicuous aspect of the general succession of forms in geological time is the continuous approximation to the character of the fauna and flora of the present day. The Cambrian fauna and flora differ widely from those of the present day. No species, and not more than one or two genera, of organisms now living existed in the Cambrian; and to a large extent even the orders and classes of the present fauna and flora were lacking in the Cambrian. As we come down through the succession of geological eras, there is a continuous ap-

---

* Heilprin, *Geological Evidences of Evolution*; Dana, *Revised Text-book of Geology*, p. 450.

proximation to the character of the fauna and flora of the present time. With this increasing resemblance of the life of successive geological periods to that of to-day, comes an increase in the number of classes and orders, and a continually increasing diversification of the types of structure. The classes and orders represented in Cambrian time are comparatively few. In the progress of geological time, very few groups, if any, entitled to rank as classes have become entirely extinct, though several classes have greatly diminished in numbers. Many new classes have been added from time to time; some orders have become extinct, but a much greater number of new orders have been added; so that there has been in general a continuous increase in the number of groups of classical and ordinal rank. This progressive diversification of the animal and vegetable kingdoms suggests the figure of a tree. In the Cambrian we have already a few great branches representing most of the sub-kingdoms that now exist; but the increase in the number of classes and orders, as we come down through geological time, reminds us of the increasing ramification which the tree exhibits as we go farther and farther from the origin of the main branches.

Not only do we find in successive geological periods an increasing number of classes and orders, but we find also in later periods an increasing number of types of high grade.* In the earlier geological periods the higher forms of life are conspicuously absent. In the

* See table on page 103.

Cambrian we find no vertebrates whatever, and in the Silurian no vertebrates above the class of fishes. Mammals do not appear until the Triassic, and the typical placental mammals probably not until the Tertiary. Among invertebrates perhaps the highest class are the insects. These are entirely unrepresented in the Cambrian, and in the Ordovician we find only one or two of the very lowest orders. Not until Mesozoic time do the higher orders of insects appear. Among mollusks the highest class, the cephalopods, begins indeed in the Cambrian, but the higher of the two sub-classes of that class, the dibranchia, not until the Triassic. The higher orders of gastropods likewise do not appear until the Triassic. In general, it may be said that the highest of the sub-kingdoms, the highest classes in the respective sub-kingdoms, and the highest orders in the respective classes, are comparatively late in their appearance. It is needless to say, this condition of things is exactly what might be expected in accordance with the theory of evolution.

Another class of paleontological facts favorable to the theory of evolution is seen in the striking resemblance which the earliest members of a class or order generally present to groups that were already in existence. The earliest amphibians were not at all like the toads and salamanders of to-day, but were in many respects much like some of the ancient fishes that preceded them. In these earliest amphibians, as in many fishes, the clavicles are still in the condition of dermal bones forming a defensive armor in the pectoral region

of the body. They had not yet come to be internal bones serving solely to brace the shoulder girdle. The earliest birds, which made their appearance in the Jurassic, showed remarkable reptilian characters. Their jaws were set with rows of teeth; the metacarpal bones (see Fig. 9) were still free and somewhat movable, as in the forefoot of a reptile, instead of being ankylosed together to make a more rigid basis for the attachment of feathers; their tails were supported by a long series of vertebræ, in sharp contrast with the tails of modern birds, whose imperfectly developed vertebræ are consolidated into a mere stump to support a fan-shaped tuft of feathers. In like manner, the earliest mammals, appearing in the Triassic, almost certainly resembled reptiles in having distinct coracoid bones, in the structure of their reproductive organs, and in their oviparous reproduction. Again, in early Tertiary time, the earliest hoofed mammals (ungulata) were scarcely distinguishable from the claw-bearing mammals (unguiculata) with which they were associated. In the highly specialized forms which have been developed in later times, the ungulates are very sharply distinguished from the unguiculate orders. In the unguiculate mammals, the radius and ulna are generally so articulated as to allow considerable rotation of the fore-arm, the bones of the hand and foot are considerably movable, the digits are almost always five in number, and each digit is armed with a claw for seizing and tearing the food, or rarely with a flat nail for protection. In the ungulates, the radius and ulna are so articulated

as to allow no rotation of the fore-arm, or even fused together into a single bone, the bones of the hand and foot allow but little movement, the digits are generally less than the typical number, being sometimes reduced even to two or one, and the end of each digit is encased in a horny box or shoe which we call the hoof. The general effect of these anatomical characteristics of the ungulates is, of course, to deprive the limbs entirely of tactile and prehensile function, leaving them to serve exclusively for support and locomotion. But in the early Tertiary the primitive ungulates have diverged so slightly from the unguiculates that it is almost by an arbitrary line that they are separated from them in the classification. Perhaps the most striking illustration of this increasing specialization of a group with the lapse of time is seen in that remarkable series of fossil forms by which we can trace the gradation from a creature with five fingers and five toes to the modern horse. In this remarkable series, the inner and the outer fingers and toes successively diminish and disappear, until only the middle finger and the middle toe are left (see Fig. 9), while the bones of the limbs increase in length, and the teeth increase in complexity.

Again, it is noticed, as a rule, in geological history that a group of animals or plants which has once disappeared does not reappear. The few apparent exceptions to this law may be readily accounted for on the principle of the imperfection of the geological record, of which somewhat will be said later.* In general, the

---

* Page 202.

introduction and the extinction of orders or classes seem to have been gradual. Each group commences with a comparatively small number of species, and increases gradually to a maximum, after which it may again decline. As has been already shown,* in tracing the overthrow of catastrophism and the rise of uniformitarianism, it has long been acknowledged that there is no reason to believe in any epoch of universal extermination since the beginning of life upon the planet. The changes that have taken place in the faunas and floras of successive eras have been not by universal extermination and new creation, but by the disappearance of old species and the introduction of new species one by one. In all these respects it is obvious that the aspect of the geological succession of life is strongly favorable to the theory of evolution.

The distribution of plants and animals in space, like their distribution in time, corresponds in general with what would be expected on the theory of evolution. The theory of evolution, of course, assumes that all the individuals of a single species are derived from a common ancestry. By this it is not meant that they are all descended from a single individual or from a single pair, for this is not likely to have been the case with any species of animal or plant; but rather that they have descended from a comparatively small number of individuals in some limited area. It is further supposed that a species, starting thus in a limited area, diffuses itself by active and passive migration until its

* Pages 155, 161.

spread is checked by impassable barriers, inhospitable climate, or unfavorable conditions of life. We should, then, expect that the range of each particular species would be continuous. As a matter of fact, we find that the range of species is generally continuous, and the exceptional cases in which the range of a species is not strictly continuous generally admit of ready explanation. For instance, if we find colonies of plants and insects that belong in Greenland or Labrador living on the higher summits of the White Mountains, or find, in like manner, colonies of plants and insects that belong in Lapland living in the Alps, the fact is readily explained by reference to the Glacial period. The northern forms of life migrated southward (actively or passively) at that time; and, when the main body of a northern species migrated northward again as the climate grew warmer, colonies that had become established on mountain summits were able permanently to maintain themselves, because the cold climate of high mountain regions shielded them from the competition of the southern forms that had taken possession of the lowlands. Moreover, according to the theory of evolution, all the species of a single genus ought to have had a common ancestry, but, in general, further back in time than we should look for the common ancestry of the individuals of a single species. We should naturally expect, then, that the range of genera would generally be continuous; but that, since the origin of a genus is likely to have been more remote in time than the origin of a species, there would have been opportu-

nity for a larger number of those geographical changes which break up the continuity of what was previously a continuous area. In general, then, the range of genera should be either actually continuous, or capable of being made continuous by such geographical or climatic changes as it is within the bounds of reasonable probability to assume to have taken place in geological time not very remote. The facts in regard to the range of genera exactly correspond with this assumption. On the other hand, the theory of evolution would imply that the origin of the more comprehensive groups, as classes and sub-kingdoms, must belong to a very remote antiquity, antedating by far the present distribution of sea and land and the development of most of the mountain ranges and other conspicuous features of the earth's surface. Since, then, the origin of these more comprehensive groups antedates the establishment of the present geographical features, we should naturally expect that the distribution of these groups would be substantially world-wide; and, again, this supposition is exactly in accord with the facts.

The bearing of the facts of geographical distribution upon the theory of evolution appears more significant when we take them in connection with the facts of geological succession. Wallace announced many years ago the remarkable proposition, that "every species has come into existence coincident both in space and time with a pre-existing closely allied species."* It would be impossible actually to prove that proposi-

* *Contributions to the Theory of Natural Selection*, p. 5.

tion in regard to every known species, since our knowledge of extinct life is so far from being complete. Nevertheless, the proposition can be shown to be true in so many instances that there is no reasonable doubt that it is to be accepted as a universal law. It is needless to say that the theory of evolution would require just such a relation as is expressed in Wallace's formula. Not only does it seem to be true that every species has come into existence in a region where there was already some nearly allied species; we find also in certain regions that the general character of whole faunas in successive geological periods presents extraordinary resemblances. In late Tertiary and Quaternary time, Australia had already become the land of kangaroos, phalangers, and wombats. Australia is today likewise the land of kangaroos, phalangers, and wombats. The Tertiary and Quaternary species have become extinct, but the same families survive. In like manner, in late Tertiary and Quaternary time, South America was the land of sloths, ant-eaters, and armadillos, and South America to-day is still the land of sloths, ant-eaters, and armadillos. Now, on the supposition that the present kangaroos are the descendants of the Tertiary kangaroos, and the present sloths the descendants of the Tertiary sloths, these facts are exactly what we should expect. Apart from the theory of evolution, it is not easy to find a satisfactory reason for such facts. The teleological suggestion that kangaroos, phalangers, and wombats are better adapted to the climate and the conditions of life in Australia than

any other animals, seems not to be true, for we know that sheep and rabbits and other creatures introduced into Australia from Europe prove so exceedingly well adapted to the climate and conditions of life in that continent that their rapid multiplication threatens to starve out many of the indigenous species.

Another consideration bearing strongly in favor of the theory of evolution is the indefiniteness of zoological and botanical classification. In the first place, there is great difference of opinion among naturalists in many cases as to the units of classification, the species. One naturalist will divide a genus into twenty or thirty species, while another will recognize only two or three species, regarding the others as mere varieties. It is a paradoxical, but nevertheless a perfectly intelligible fact, that the difficulty in the delimitation of species is greatest in those groups of animals and plants which have been most thoroughly studied, and in the faunas and floras of those regions of the earth which are best known. If a traveler makes a hasty journey through some hitherto unexplored part of central Africa, and brings back such specimens as his caravan can readily transport, it will generally be found that he has collected only a single specimen, or at the most a few specimens, of each species; and a naturalist who classifies and names them will find it easy to determine how many species are represented, since almost every specimen will represent a distinct species. But, in a country like England or New England, where hundreds or thousands of specimens of most species of plant and

animal have been collected and examined, it will often be found that some of the specimens of any one species vary considerably from the average character of their own species, and approach more or less the character of some allied species. The greater the number of specimens collected, the more likely are such gradational forms to appear; and, with the appearance of such gradational forms, the question arises whether we are dealing with a number of species, or with a single species presenting a number of varieties. That is exactly what we should expect on the theory of evolution, and exactly what we should not expect apart from the theory of evolution.

When we turn our attention from the taxonomic unit, the species, to the more comprehensive groups—when we consider the division of the animal or the vegetable kingdom into sub-kingdoms, classes, orders, and families—it is perfectly safe to say that no two naturalists can agree in all details upon a classification either in botany or in zoology, unless they reach an agreement by the same method of compromise by which political conventions construct platforms and ecclesiastical assemblies construct creeds. By mutual compromise, two or more naturalists may, of course, construct a classification of the vegetable or the animal kingdom, which will not represent exactly the opinions of any one of them, but which no one of them will think very bad. Groups of plants and animals that seem to be clearly marked by trenchant characters, when we consider only their most typical members,

seem in some of their aberrant forms to blend with each other like the colors of the spectrum.

These are some of the aspects of organic nature that are eminently suggestive of the theory of evolution. As has been already said, the limits of this discussion have allowed only an inventory of the classes of evidence. The cumulative force of that evidence reveals itself only in prolonged study of some one or other of the departments of biology.

The mass of evidence which organic nature affords in favor of evolution is usually met by the opponents of evolution with a single stock argument. They say that, if one species is derived from another species, we ought to find close gradations between different species; and this, they tell us, we do not find. A species is usually clearly marked. There is no danger of mistaking a tiger for a leopard, or a grizzly bear for a polar bear.

It is, however, not true, in the unqualified way in which that proposition is often asserted, that species are sharply marked, and that intermediate stages are wanting. The fact to which reference has already been made, that naturalists often differ widely as to the number of species included in a well-known genus, shows that species are not limited in all cases in the definite and unmistakable way which is often asserted. There are, indeed, few better examples of the logical fallacy of reasoning in a circle, than the way in which the evidence afforded by gradational forms is disposed of by the opponents of evolution. If, between two

types which differ considerably from each other, and which have been confidently supposed to be distinct species, further investigation discovers a series of gradational forms, those two extreme types with all the intermediate gradations are combined into a single species, which is then said to be widely variable. And then the anti-evolutionist is able to affirm that, while there are gradations between varieties, there are no gradations between species. Of course the evidence of gradation between types that appear very distinct is not lessened by giving to the extreme types one specific name instead of two. The fact of gradation is suggestive of evolution, however much it may be disguised by a change of nomenclature.

Nevertheless, though the assertion that species are definitely limited is not true in the unqualified way in which that assertion is often made, it does appear to be true of the larger number of existing species. As a rule, we do not find a series of fine gradations between two existing species. But, according to the theory of evolution, we ought not to expect in most cases to find such a series of gradations. The evolutionist does not assume, in general, that one species has been derived from another species which still exists. Only under exceptional conditions could that be the case. As we have already seen, the condition of the evolution of a new species is that the environment should have so changed that the parent type is no longer in harmony with it. As a rule, then, the very condition that gives rise to the evolution of a new

species secures the extinction of the old species. An exception to this rule would be found in a case in which some members of a species became in some way isolated from the remainder of the species, and the two groups isolated from each other were exposed to somewhat different environment. In such cases a new species might be developed in one area, while the parent species might survive in another. In this way may be explained the frequent occurrence of peculiar species in islands, while the nearly allied species from which they have probably been derived still survive on the mainland. But it is obvious that in the majority of cases the evolution of a new species must be accompanied by the extinction of the parent species. We ought, then, to expect as a rule no fine series of gradations between existing species.

This answer, however, only shifts the difficulty to another point. If we have at the present time two closely allied species, *A* and *B*, the probability is not that *A* was derived from *B*, or that *B* was derived from *A*, but rather that each of the two existing species was derived from some species *C*, now extinct. While, therefore, there is no reason to expect a series of gradations between *A* and *B*, there must have existed in the past a series of gradations more or less close between *C* and *A* and between *C* and *B*. The theory of evolution, then, requires a series of more or less fine gradations between every species and some other species that preceded it in geological time.

It must be admitted that, in the great majority of

cases, we do not find any such gradational forms preserved as fossils. In general, if allowance is made for the fragmentary and imperfect character of the material with which the paleontologist has to deal, species of fossil organisms appear to be fully as well defined as those of living organisms. And not only do species appear in geological history without any series of gradational forms connecting them with pre-existing species, but in many cases more comprehensive groups, as orders or classes, appear to flash suddenly into existence with no more recognizable trace of ancestry than if they were so many Melchizedeks. The most startling of all cases of this sort is the Cambrian fauna. Prior to the Cambrian we find only obscure and doubtful traces of life, but in the beginning of the Cambrian we find already a highly diversified fauna of marine invertebrates. In statistical comparisons of fossil faunas with the existing fauna, those groups must obviously be thrown out of account whose members possess no skeletons, since it is only under very exceptional conditions that such groups can be represented by fossils.* In the scheme of classification adopted in Parker and Haswell's "Text-book of Zoology," there are nine phyla or sub-kingdoms, and twenty-nine classes, some or all of whose members possess skeletal structures sufficiently developed to entitle them to be included in such a comparison. It is certainly an astonishing fact that seven out of these nine sub-kingdoms, and fourteen

* The improbable does sometimes happen. Fossil jellyfishes occur in the Cambrian, and in later formations.

out of these twenty-nine classes are represented in the Cambrian.*

Darwin, in his "Origin of Species," declared that, in his view, such paleontological facts as those just cited afforded the "most obvious and serious objection" against his theory. It is certain that the facts of paleontology appear far more favorable to the theory of evolution to-day than they did forty years ago, for the progress of discovery has brought to light a vast number of intermediate forms between types previously known, and has bridged many of the most conspicuous gaps. Nevertheless, so many gaps still remain unbridged that Darwin's answer to the objection, as it presented itself to his mind, is still appropriate; and indeed our belief in evolution must stand or fall according to the sufficiency of that answer. Darwin's answer to the paleontological objection to evolution was given in a chapter of his book the title of which has now become classic—"The Imperfection of the Geological Record."† By that phrase he meant that the fossils which have been collected and preserved in museums are not, as is vaguely supposed by those who

* The seven sub-kingdoms represented are Porifera, Cœlenterata, Molluscoida, Echinodermata, Annulata, Arthropoda, Mollusca. The classes represented are Porifera, Hydrozoa, Actinozoa, Brachiopoda, Asteroidea, Crinoidea, Cystoidea, Chætopoda, Crustacea, Trilobita, Arachnida, Pelecypoda, Gastropoda, Cephalopoda. All these groups except the Asteroidea, Crinoidea, Arachnida, and Cephalopoda, were represented in the Georgian, the lowest of the three divisions of the Cambrian. The absence of the sub-kingdom Protozoa and class Rhizopoda from this list is remarkable. On *a priori* grounds, it would seem highly probable that they were in existence, but their existence has not yet been proved by the evidence of well-characterized fossils. In this statement I have followed the classification of Parker and Haswell, since their excellent text-book is widely accepted as a standard, though I do not in all respects agree with the views of which the classification is the expression.

† Ch. ix in the earlier editions, ch. x in the later editions.

have never studied the subject, an approximately complete representation of the faunas and floras of the past, but are in fact only an infinitesimal remnant of those faunas and floras. The sentence in which Darwin sums up his conclusions in regard to the imperfection of the geological record is worth quoting entire:—"I look at the natural geological record as a history of the world imperfectly kept, and written in a changing dialect. Of this history we possess the last volume alone, relating only to two or three countries. Of this volume only here and there a short chapter has been preserved, and of each page only here and there a few lines." I believe that this sentence is no exaggeration; that, in fact, it hardly does justice to the extreme incompleteness of that record of past life which is afforded us by fossils.

A striking testimony to the imperfection of the geological record is borne by the fact that multitudes of fossil species are known only by single specimens. Of course we must suppose that every species that ever existed included many millions of individuals; and, if an extinct species is now represented in our collections only by a single specimen, the fact shows at once that our collections of fossils are but an infinitesimal remnant of the life that has existed. But not only is it often the case that a species is represented by only a single specimen; oftentimes, in some particular formation, a whole order, or even a whole class, may be represented by a very small number of specimens. In the Jurassic era in Europe, the class of birds is

represented by two somewhat imperfect skeletons and one odd feather. The same class is represented in the Jurassic of North America by a single fragment of a skull. The class of mammals in the Triassic of North America is represented by two lower jaws. In the Subcarboniferous formation of Germany has been discovered a single tolerably well preserved specimen of a small creature which has been named *Bostrichopus antiquus*. The creature appears to have been an arthropod, yet it is so extremely different from any other known animal that we cannot with any confidence place it in any of the recognized classes of arthropods. Of course we must believe that the species to which this remarkable relic belongs was represented by multitudes of individuals, and it is likewise altogether probable that there must have been some considerable number of more or less closely allied species. It is exceedingly improbable that a single aberrant species should have existed in absolute isolation.

The instances above given are illustrations of the fact of the imperfection of the geological record. A little reflection will show that, in the nature of the case, the geological record must necessarily be very imperfect. In the first place, there are biological conditions which render an approximate completeness of the geological record impossible. That an individual organism should be preserved in fossil condition, it is necessary in general that it should be buried by sedimentary accumulations formed under water before its material has been completely decomposed or dissolved.

It is obvious that in the vast majority of cases plants and animals die under such conditions that their preservation as fossils is absolutely impossible. It is evident that the chances of fossilization are much greater, other things being equal, in the case of a marine organism than in the case of a terrestrial organism; and it is a fact that in all formations, even the latest, our record of the history of terrestrial organisms is scanty indeed. Again, it is true, in general, that only the hard parts or skeletons of organisms can be preserved. Hence those groups of plants which contain little or no woody fiber in their tissues, and those groups of animals which are destitute of shells, bones, teeth, or other considerably indurated skeletal structures, have scarcely any chance of preservation as fossils. This consideration obviously renders it impossible that we should have anything approaching a complete representation of the genealogy of either animals or plants. The mystery of the Cambrian fauna, as has been suggested by Mr. Charles Morris* and by Professor Brooks of Johns Hopkins University,† probably admits of at least partial explanation in the line of the principle just stated. It is a fact well known to zoologists that almost every important group of marine invertebrates, though the animals in their adult condition may be of large size, and have heavy skeletons, and live at the bottom of the sea, is characterized by a form of larva which is minute and destitute of skeleton, and which swims freely at or

* *Life before Fossils*, in *American Naturalist*, vol. xxx, pp. 188, 279.
† *The Origin of the Oldest Fossils and the Discovery of the Bottom of the Ocean*, in *Journal of Geology*, vol. ii, p. 455.

near the surface of the sea. According to the principle which has been already referred to,* that larval and immature forms of animals are likely to resemble more or less closely the ancestors whence those animals have been derived, it is argued with great force that the earliest ancestors of each of these groups of marine animals must have been characterized by minute size, the lack of any considerable skeletal development, and a free-swimming life at the surface of the water. Such forms could obviously not be preserved as fossils. In accordance with this reasoning, we may conclude that the probable cause of the absence of any fossils representing the ancestors of the Cambrian fauna is that those ancestors were incapable of being preserved as fossils. The fossil record of marine life commences only at that stage of evolution in which some groups of organisms had already developed skeletons of considerable weight and hardness, and had already exchanged their free-swimming life at the surface for a more sluggish life at the bottom of the sea.

There are also geological conditions which render impossible a complete record of the life of past ages. Many of the sedimentary rocks are altogether unsuited to the preservation of fossils. Coarse-grained sediments, as sands and gravels, are so porous that any shells or other remains of living things which they enclose are likely to be dissolved out; and the irregular surfaces of such deposits are incapable of preserving any delicate impressions. Recognizable fossils are

---

* Page 183.

chiefly found in the fine-grained shales, which are formed by the consolidation of mud beds, and in the limestones, which result from the accumulation of debris of shells and corals and other marine skeletons. But, after a record has been actually formed in fossiliferous strata, it is liable to obliteration. Whole series of strata may in places be disintegrated and destroyed by the agencies of the atmosphere and water. The large areas of the earth's surface occupied by plutonic and metamorphic rocks bear unmistakable testimony to the fact of enormous denudation, since such rocks could only have assumed their characteristic structure under the pressure of hundreds or thousands of feet of superincumbent rock. Other fossiliferous rocks may have had their fossils entirely obliterated by metamorphism; and still other fossiliferous deposits are now covered by the sea or buried beneath superincumbent strata, where they will probably never be accessible to human investigation.

It is, moreover, probable that not only species, but genera and even more comprehensive groups, may have been in their origin confined to limited areas. If there were in process of formation in some particular locality, at a particular time, no fossiliferous rocks which have been preserved, and which are now accessible to geological study, there would be no record of the early stages of existence of a group of organisms originating then and there. The earliest accessible record of such a group might be made after they had already become widely diffused and had become dif-

ferentiated into a considerable number of species. In this way may be explained the frequent occurrence in geological history of groups already represented by a considerable number of species, of whose ancestry no record appears.

It has already been pointed out* that there is no reason to believe that the process of evolution has gone on with equal rapidity through all geological time. On the contrary, since the condition of the evolution of new species is the lack of harmony between existing species and their environment, it must be supposed that rapid evolutionary changes take place, for the most part, only in times of rapid geographical change. In the light of this consideration, we recognize the profound significance of the fact which has already been referred to,† in discussing the doctrines of catastrophism and uniformitarianism in geology, that the most abrupt changes in fossil faunas and floras usually occur at just those points where the series of sediments is interrupted by unconformability. As has been already explained, the meaning of unconformability is that a region where strata have been in process of deposition is carried above the water level by crustal movement, and for a greater or less period of time exposed to erosion. A later crustal movement depresses the region again below the water level, and the process of deposit of sedimentary strata is resumed. The whole interval of time in which elevation, erosion, and subsidence have taken place is left unrecorded. It will

* Page 174.

† Pages 52, 155.

be noticed that the case is not merely that a period of time of greater or less length is left unrecorded. It is a period of time in which extensive geographical changes have been in progress, and in which, therefore, the processes of evolution have doubtless been going on with exceptional rapidity. It is precisely at the critical epochs of most rapid change that the geological record generally fails us. Darwin's figurative suggestion* of the historical volume, most of whose leaves have been torn out, may well admit of amplification. The chapters that have been torn out are precisely those which should record the most critical events, the most rapid changes. The natural geological record is much like a history of the United States in which the chapters on the Revolution and the Civil War have been torn out.

In view of all these considerations, it can scarcely be doubted that Darwin's principle of the imperfection of the geological record is an amply sufficient answer to that objection to the theory of evolution which is based upon the absence of series of finely gradational forms between species and between more comprehensive groups in geological history.

We have thus far discussed none of the supposed agencies of evolutionary change excepting the Darwinian principle of natural selection. That principle is obviously independent of any theory as to the cause of variation in general, or as to the cause of variation in any particular direction. The theory of natural se-

* Quoted on page 203.

lection simply recognizes the unquestionable fact that variations continually occur, no two individuals being exactly alike. Darwin spoke of variation as fortuitous. The expression was an unfortunate one, since people who did not understand his real meaning charged him with representing that variations occurred by chance. It is needless to say that Darwin had no such meaning. By fortuitous variation Darwin only meant variation whose causes are so completely unknown that we can see no reason why it should be any more likely to be in one direction than in another. It would have been better if he had said indefinite, or indeterminate, variation, instead of fortuitous variation. But, while the theory of natural selection does not itself postulate any cause of variation in any particular direction, it is yet entirely consistent with the belief that there may be known or unknown causes tending to produce variations in a particular direction. There may be, then, definite, or determinate variation. It is obvious that the evolution of new species would be aided by any causes tending to produce determinate variation in desirable directions. Natural selection would in that case have better material to work upon, and would therefore more readily produce the result.

Several supposed causes of determinate variation have been suggested. Some of the Greek philosophers, who indulged in crude and vague evolutionary speculations, assumed the existence in all organisms of an innate tendency to improvement, the result of which would be a continuous progress from lower to higher

forms of organization. Innate tendencies, however, are not looked upon with as much favor in the philosophy of to-day as in that of two thousand years ago; and a suggestion so vague and so incapable of verification is of no value as a scientific hypothesis. There are, however, two supposed causes of determinate variation which are worthy of serious consideration. The first of these is the direct effect of the environment. This was urged as the main cause of evolutionary change by some of the early French evolutionists, notably by Buffon in the eighteenth century, and by Étienne Geoffroy Saint Hilaire in the early part of the nineteenth century. Differences in climate, food, and other conditions of life appear to produce, in many cases, during the life of the individual, conspicuous differences, in man himself and in domestic animals and cultivated plants. The importance of these direct effects of environment has been greatly exaggerated by some writers; but the effects are real, and especially important in the case of plants. Buffon, Saint Hilaire, and others, recognizing the fact of the changes thus produced in the lifetime of the individual by the action of the environment, assumed that the effects of those changes would be in greater or less degree inherited by the offspring.

Lamarck claimed that the most important factor in the evolution of animals is not the direct effect of environment, but the indirect effect. The environment compels the individual to adopt certain habits and modes of life, and those habits produce in time perma-

nent changes in the organism. Lamarck held that these indirect effects of environment are capable of being inherited, and can therefore be accumulated from generation to generation. He explained the long neck of the giraffe by assuming that the ancestors of the giraffe, living for generation after generation in a region where grass was scarce, and subsistence could be obtained only by browsing on the leaves of trees, had continually stretched their necks in thus seeking their food; and that the effect of the habit, after many generations, had been a change from a primitive form, which may have been not unlike that of an antelope, to the present form of the giraffe. One phase of the Lamarckian doctrine which is especially important is the effect of use and disuse. Every one knows that, in general, those organs that are much used tend to increase in size and in perfection of development. The arm of a blacksmith is a very different organ from that of a sedentary student, and the brain of the scholar is a far better organ than that of a man who has never developed an idea beyond the simple manual labor which secures his daily food. The special doctrine of Lamarck as to the indirect effect of environment upon organization by means of habit can, of course, apply only to the animal kingdom. Lamarck's theory of the evolution of plants was essentially the same as that of Saint Hilaire and Buffon. The chief agency was supposed to be the direct influence of the environment.

Both Saint Hilaire's principle of the direct effect

of environment and Lamarck's principle of the indirect effect of environment require the belief that characters acquired during the life of the individual are capable of being inherited. The question of the truth of this assumption will be considered presently.

In regard to the validity of the factors of evolution assumed by Saint Hilaire and Lamarck, evolutionists since Darwin have been divided somewhat definitely into three schools. Darwin himself, though maintaining that his own principle of natural selection was by far the most important factor in the evolution of new species, believed in the validity of both the direct and the indirect effects of environment, as assumed by Saint Hilaire and Lamarck; and those evolutionists who in this respect adhere to Darwin's views may reasonably call themselves Darwinians. From this position of Darwin a departure has been made in two different directions. The Neo-Lamarckian school believe the direct, and especially the indirect, effect of the environment to be very much more important than Darwin supposed, while they relegate natural selection to a comparatively subordinate position among the agencies of evolution. In their thought, natural selection preserves the fittest, but the origin of the fittest is to be found in the operation of the Lamarckian factors. On the other hand, the Ultra-Darwinian, Neo-Darwinian, or Weismannian, school utterly repudiate both the direct and the indirect effect of environment, holding that variation is absolutely indeterminate, and

that natural selection is the sole agency in evolution.* I believe that the departure in each of these opposite directions from the position of Darwin is in the direction of error. I believe that Darwin was right both in maintaining the paramount importance of natural selection, and in conceding the validity, within limits, of the factors of evolution asserted by Saint Hilaire and Lamarck.

As has been remarked, the evolutionary theories of Saint Hilaire and Lamarck involve as an essential condition the inheritance of characters acquired during the lifetime of the individual. Unless that postulate is granted, the effect of the environment, direct or indirect, ceases with the individual life, and no tendency to determinate variation can arise therefrom. Until recently it has generally been taken for granted, alike by scientists and by the general public, that acquired characters are capable, at least in some degree, of being inherited. But, when the question comes to be seriously considered, it becomes obvious that the evidence of such inheritance is far less conclusive than has generally been supposed.

Perhaps the strongest evidence of the inheritance of acquired variations is seen in the hereditary instincts of domestic animals. The condition of tameness appears to be hereditary. The offspring of our domestic animals appear to have inherited that condition of the

---

* Cope, *Origin of the Fittest*, and Weismann, *Essays upon Heredity and Kindred Biological Problems*, may be referred to as representative of the extreme views. For a convenient summary of the various recent discussions on evolution, see Conn, *Method of Evolution*.

nervous system which in their ancestors was the result of habits of association with man. The more specific instincts developed in certain breeds of domestic animals afford an indication in the same direction. It has been repeatedly observed that young pointers of pure blood are apt to assume the characteristic attitude of pointing when first taken into the field. It is difficult to understand the fact except on the supposition that a habit which was originally the result of training has produced in the ancestors of these dogs a heritable modification of the nervous system by which the acquired habit has become a hereditary instinct.

It seems probable also that some of the instincts of wild animals may best be explained in like manner, as held by Darwin, Romanes, and others, by the supposition of the inheritance of habits formed primarily by intelligent response to the conditions of the environment. The phrase, "lapsed intelligence," first used by Lewes,* felicitously expresses the psychological condition involved in such "inherited habits." There are, however, some instincts for which this explanation is certainly inadmissible. The origin of instincts is confessedly a difficult problem; and, while the facts afford some evidence in favor of the inheritance of acquired characters, the evidence is certainly not conclusive.†

There are multitudes of supposed instances of in-

---

* *Problems of Life and Mind.*

† On the evolution of instincts, see Darwin, *Origin of Species*, ch. vii in the earlier editions, ch. viii in the later editions; Romanes, *Mental Evolution in Animals;* Morgan, *Animal Life and Intelligence;* Morgan, *Habit and Instinct.*

heritance of acquired characters in human life, which, when examined, are found to be very uncertain. It is a familiar fact that there are families of drunkards, families of criminals, families of musicians, families of statesmen, families of scientists. In all these cases it is often hastily assumed that the habits of life of the parent produce modifications of the nervous system which are inherited. The inference, however, is seen to be uncertain for two reasons. In the first place, granted that the character of the offspring in these cases has been largely controlled by heredity, it is altogether uncertain whether the child inherits the effects of the parent's habits, or inherits only the congenital tendencies which led the parent into the formation of those habits. In the case of hereditary drunkenness, it can never be decided whether the child inherits a condition which is the result of the father's habit of drunkenness, or inherits only that nervous weakness or abnormality which existed congenitally in the father and which made him an easy prey to temptation. The other element of uncertainty, in all these cases of apparent inheritance of marked peculiarities in the human species, lies in the impossibility of distinguishing how much of the character of the offspring is due to heredity and how much to environment. In the vast majority of cases, the parents of a child have the largest share in the shaping of his environment. They are his first and chief teachers in that process of conscious and unconscious education by which his life and character are largely formed. Their example is the one

which he naturally follows, even when the following of their example is not sedulously inculcated as a duty. The only cases in which it is practicable to discriminate between the effects of heredity and those of environment, are the exceptional cases of orphans and others who are reared under the dominant influence of other persons than their parents. The success which has been attained in many orphan asylums and similar institutions, in developing into very respectable men and women children whose ancestry was the worst possible, is eminently suggestive of the idea that, in general, environment is a weightier factor than heredity in shaping the lives and characters of human beings.

In recent years Weismann and his followers have denied on theoretical grounds the possibility of the inheritance of acquired characters in any degree whatever.* According to Weismann's theory of heredity, there is in each individual organism a complete physiological isolation of the portion of the body whose function is to reproduce the species from the portion of the body which carries on the activities of the life of the individual. In every ovum there is a certain portion of material which is destined to develop into the various organs by which the life of the individual is to be maintained and its activities to be exercised. That portion of the substance of the egg is called the somatoplasm. Another portion of the substance of the ovum is destined to have no share in the activities of

* Weismann, *Essays upon Heredity*. Weismann's views are trenchantly criticized by Romanes, *Examination of Weismannism;* also *Darwin and After Darwin*, vol. ii.

the life of the individual, but is simply stored up for the production of future generations. It is, in other words, to constitute the reproductive products. That portion of the ovum is called the germ-plasm. According to Weismann's theory, through all the life of the individual, the somatoplasm and the germ-plasm are so completely independent of each other that the changes wrought in the somatoplasm by the direct and indirect effects of the environment can have no tendency to induce corresponding changes in the germ-plasm, and therefore cannot reproduce themselves in the offspring. According to this theory of inheritance, the offspring can inherit only what was congenital in the parent, for only the congenital characters of the parent can find expression in the germ-plasm. It is impossible here to enter at length into the discussion of Weismann's theory. Suffice it to say that it does not seem probable that there can be that complete physiological isolation of somatoplasm and germ-plasm which Weismann's theory assumes. It is indeed true that in most animals the reproductive organs and products are anatomically differentiated from the rest of the body at a pretty early stage in embryonic life. In plants, however, the case is very different. The reproductive organs and products are usually not anatomically differentiated until a relatively late period in the life of the organism. But even in animals, in which the reproductive products are very early differentiated anatomically, it seems highly improbable that they can be so completely isolated physiologically from the rest

of the organism in which they live, and by which they are nourished, as not to be affected in any definite way by the modifications which that organism experiences.

It appears, on the whole, probable that acquired variations are capable in some degree of being inherited, though probably in far less degree than Saint Hilaire and Lamarck supposed, and in less degree even than Darwin conceded. The line of investigation that seems most likely, in the near future, to yield somewhat definite information in regard to the degree in which acquired variations are capable of being inherited, is the cultivation of plants under an environment different from the ordinary environment of the species. In many respects experiments on plants are more easily carried out than experiments on animals. It is well known that many plants, when cultivated in an environment very different from that of the parents (as, for instance, when plants which normally grow in the interior of a continent are cultivated on the seashore), exhibit strongly marked peculiarities in foliage and in other respects. If acquired characters are capable in any degree of being inherited, it ought to follow that, when the plants have been exposed for a number of years to the changed environment, their seeds, if planted in the normal environment of the species, would produce plants which would exhibit in some degree the characters which their parents had acquired in the abnormal environment. It would seem that a series of experiments of this sort, involving a considerable number of species of plants, and continued

for some considerable term of years, might yield somewhat definite results in regard to the degree in which acquired variations are inherited.

It must be noticed that an element of uncertainty has been shown to exist in all the supposed evidences of inheritance of acquired variations, by reason of the principle not very felicitously named "organic selection," whose discovery has been independently announced by Professor J. M. Baldwin,* of Princeton, Professor Henry F. Osborn, of Columbia University, and Professor C. Lloyd Morgan, of Bristol, England. Let us suppose that some geographical movement or other change has thrown the character of a species out of harmony with its environment. Those individuals of the species whose physical or psychical constitution is sufficiently plastic, will respond to the change in environment by changes directly effected in the organism, or by changes of habit and consequent changes in the organism. In other words, the plastic individuals will experience adaptive modifications in one or both of the methods asserted respectively by Saint Hilaire and Buffon. Natural selection will then operate to preserve the individuals thus adaptively modified, and to destroy the unmodified individuals. These modifications, indeed, according to the Weismannian doctrine, can be in no degree inherited. Nevertheless, in the second generation, and in every subsequent genera-

* Baldwin, *Development and Evolution.* In this work Professor Baldwin's original papers are republished; and, in the Appendix, copious extracts are given from the writings of Professors Osborn and Morgan and others who have treated the subject of organic selection.

tion under the new environment, the same adaptive modifications will be produced in the individuals sufficiently plastic, and in each generation natural selection will tend to preserve the individuals thus modified. On the supposition that congenital variations are absolutely indeterminate, it may be expected that in process of time there will appear congenital variations in the same direction as the adaptive modifications. Then, and not till then, according to the Weismannians, can the new characters be transmitted by inheritance. But in the meantime the race will have been preserved from extinction, under the changed environment, by adaptive modifications effected in each generation. It thus appears that the persistence, for an indefinite series of generations, of characters such as are produced in the individual by the direct or indirect action of the environment, is not conclusive proof of the inheritance of acquired modifications. There seems no doubt that the principle of organic selection is sound, though there is much uncertainty in regard to the importance of its effects. It has been claimed by Professors Baldwin and Morgan to be especially valuable in accounting for the development of instincts. The theory of organic selection has been spoken of as a compromise between the Neo-Lamarckian and the Ultra-Darwinian school. A compromise in some sense it certainly is, but a compromise in which the Neo-Lamarckians surrender far more than their adversaries. The conception of evolution from the standpoint of organic selection is superficially Lamarckian but fundamentally

Darwinian. It is Lamarckian in asserting the importance of adaptive modifications effected by the action of the environment in the life of the individual, and especially in asserting the importance of the conscious activity of the individual; but it is essentially Darwinian or Weismannian in making the evolution of new species depend upon the preservation of indeterminate variations by natural selection.

Laying aside for the present the supposition of determinate variation, we may consider the question whether natural selection would be adequate to develop a new species by means of purely indeterminate variations. Some strong objections have been alleged to the adequacy of natural selection in the absence of determinate variation.*

A plausible objection to the adequacy of natural selection is found in the fact that in many cases specific characters give their possessors no obvious advantage in the struggle for life. It is, indeed, perfectly intelligible that the white fur of the polar bear gives the creature a far better chance of survival in its environment than it would have if it were as dark as its congener, the black bear. But in multitudes of cases it is impossible to discover any utility in the particular color pattern and other details of ornamentation which characterize a particular species. On the other hand it may be answered, so imperfect is our knowledge of the delicate adjustments of organic nature, that he would be a rash man who should deny the possibility of some

* Mivart, *Genesis of Species.*

real utility in characters apparently so trivial as a white bar on a bird's wing or a pair of white feathers in its tail, and still more rash would he be who should deny the possibility that such characters might be correlated with other characters of great utility. But it must be confessed that the appeal to ignorance, though sometimes reasonable and necessary, is not a very satisfactory argument. In this connection it is proper to remark that there has been a good deal of superfluous discussion on the question what degree of utility is necessary to give to a character "selective value." The slightest degree of utility gives selective value to a character. Natural selection does not require a variation of such critical importance as to preserve the lives of its possessors in a general massacre of the remainder of the species. It is enough that a variation should enable its possessors to attain a slightly greater average longevity, and to leave a slightly greater average number of offspring. Any character that increases, however slightly, the comfort of its possessors, must improve their general tone of health and vigor, and so give them a greater average longevity. An extra inch in the length of the tail of a mammal which uses its tail as a fly-brush, may have selective value.*

A similar, and perhaps a more cogent, argument against the adequacy of natural selection may be stated in the proposition that incipient stages of organs would not as a rule be useful in any appreciable degree, even though the perfect organ might be of great utility, and

* Conn, *The Method of Evolution*, p. 85.

that the incipient stages would therefore be incapable of being preserved by means of natural selection. The fins of fishes must have been in their primitive condition simply very slight folds of skin, and it has been argued that such slight folds of skin would be of no use as fins or for any other purpose, and that therefore there would be no reason why natural selection should preserve them. I cannot help thinking that Darwin assumed an unnecessary burden in practically limiting himself to the supposition of minute variations. It is undoubtedly true that the majority of variations are insignificant, but nevertheless it is a matter of common experience that from time to time very marked variations do appear. Offspring are occasionally produced which differ very widely indeed from their parents. Two of the most remarkable instances of new breeds among domestic animals developed in recent times have originated from strongly marked variations of this sort. One of these cases is that of the so-called ancon, or otter, sheep, a breed formerly common in New England, though more recently displaced by breeds imported from Europe. The otter sheep originated in 1791 from a single lamb which attracted the attention of its owner by the shortness of its legs. The enterprising farmer conceived the idea that a short-legged breed of sheep would be desirable, since they would be less likely to jump fences than the longer-legged race. He accordingly reared the strange lamb to maturity, and bred from that individual with such success as to start a well characterized breed of short-

legged sheep. The black-shouldered variety of peacocks is known to have originated in a similar way, by the sudden appearance of a number of birds whose plumage departed very widely from the parental type. There seems to be no reason why such variations may not occasionally take place in a state of nature, and why they may not be of some significance in the process of evolution of new species.*

Another objection to the adequacy of natural selection is found in the fact that the utility of a specific character often depends upon the mutual adaptation of characters of various organs and tissues. A deer's antlers may be useful; but, if the antlers were developed without the development of the muscles and bones of the neck and shoulders in such wise as to enable the creature to wield the antlers, they would be not only useless but pernicious.† This objection has weight in regard to variations of organs of exquisite complexity, as the eyes of vertebrates or cephalopods. The objection finds at least a partial answer in the principle which Weismann has called "intra-selection."‡ By this word he denotes a certain plasticity of the organism, whereby, in the development of the individual, various organs and tissues grow in mutual correlation. If a deer were produced with a congenital variation in the direction of a tendency to heavier antlers, the weight of the antlers would cause a stronger development of

* See Bateson, *Materials for the Study of Variation.*
† Spencer, *Principles of Biology*, vol. i, p. 514.
‡ Romanes Lecture, *The Effect of External Influences on Development*, 1894, pp. 11, 18.

the muscles of the neck, and that in turn would induce modifications in the bones to which the muscles were attached. According to this view, a congenital and heritable variation in one organ may be rendered useful by correlated modifications in other organs, which, though not inherited, are independently developed in each individual. There is an obvious analogy between Weismann's doctrine of intra-selection and the theory of organic selection already discussed.* Each of the two conceptions is in some sense a mediation between the Lamarckian and the Darwinian conception of evolution.

A fourth objection to the sufficiency of natural selection is that any variation, however desirable, is not likely to be preserved and made the starting point for the development of a new species unless it occurs simultaneously in a considerable number of individuals.† Suppose that in some species the relation between the rate of reproduction and the rate of mortality is such that, on the average, one in every thousand of the organisms hatched from the egg survives to maturity. Suppose an individual is produced which has varied in a manner so desirable as to give it twice as good a chance of surviving in the struggle for life as the average of the individuals of the species. It will still, as has been argued, have only one chance in five hundred of surviving to maturity. If a single individual or a few individuals possessing some desirable variation should survive to maturity, it is further claimed that

* Page 220.

† *North British Review*, June, 1867.

the desirable variation would nevertheless disappear in the course of a few generations by promiscuous crossing with the vast multitude of individuals of the species which do not possess the variation in question. The conclusion suggested by this line of reasoning is obviously that, in order that a variation may be preserved by natural selection and made the basis of the evolution of a new species, it must appear simultaneously in a considerable number of individuals. Apart from merely quantitative variations in the development of an organ or character which has already been acquired, it seems improbable that like variations will appear simultaneously in individuals, unless there be some cause of determinate variation.

Without denying that this argument possesses great force (as was early acknowledged by Darwin himself),* it may be noticed that in many cases the action of natural selection may be greatly assisted, as has been pointed out by Romanes and Gulick,† by the isolation of the individuals that have varied in any particular direction, and the consequent prevention of their crossing with other individuals of the species. There may be, in fact, various kinds of isolation. There may be geographical isolation, as when a small colony of the individuals of a species is established on an island, the home of the majority of the species being on an adjacent continent. As the average character of the small colony on the island will practically never be exactly

* *Origin of Species*, 5th (American) edition, p. 93.
† Romanes, *Darwin and After Darwin*, vol. iii.

identical with the average character of the main body of the species, the insular colony will start on its history in a different condition from that of the main body of the species. In most cases also its environment will be more or less different from that of the continental portion of the species. Thus we can readily understand the evolution of peculiar species in insular situations as a result of geographical isolation. But there may be other forms of isolation where geographical isolation does not exist. There may be a topographical isolation within the same continuous area. If certain individuals of a species vary in such a way that they choose a different station, that difference of station may so isolate them from the mass of the species as in great degree to prevent their crossing. If, for instance, certain individuals of a species, in consequence of some variation, tend to live on higher ground or on lower ground, in places more dry or in places more damp than the stations frequented by the mass of the species, there will be an obvious tendency for the individuals that share the variation to breed with each other, while their crossing with other individuals not possessing the variation in question will be more or less effectively prevented. There may be, again, physiological isolation, where there is no local isolation, either geographical or topographical. If certain individuals in a species of flowering plant vary in such wise as to blossom a little earlier or a little later than the other members of the species, that difference in the time of flowering will operate to prevent crosses

between individuals which do possess and individuals which do not possess the variation in question. In the case of the higher animals, the act of pairing is governed in large degree by psychological conditions; and, if certain individuals vary in any way that renders them less attractive to the other individuals of the species, or if certain individuals develop a variation correlated with some peculiarity of instinct which makes the other members of the species less attractive to them, the result will be that the two kinds of individuals within the limits of the same species will be more or less effectively prevented from crossing.

There is one very broad fact in natural history which seems to indicate that physiological isolation has had much to do with the development of species. In one respect species existing in nature differ widely from breeds which have been produced in domestication. In the case of distinct species it is certainly the general rule that the blending of two species is resisted by a greater or less degree of sterility. In the majority of cases an attempted cross between individuals of two species, whether animal or vegetable, results in the production of no offspring whatever. In some cases, offspring is produced, as in the well-known case of the mule, which is the result of a cross between two nearly allied species, the horse and the ass. But, in the cases in which a hybrid offspring is produced, it is usually found that the hybrids are themselves incapable of producing offspring. Even in the cases in which a second generation has been produced, there appears, in gen-

eral, an obvious tendency for the hybrid race to die out by reason of increasing sterility in successive generations. While there is no sufficient evidence to warrant the assertion of a universal sterility of hybrids, it is certainly the general law that the crossing of distinct species is opposed by a condition of sterility greater or less in degree. On the other hand, there appears to be no tendency to sterility in the case of the crossing of different breeds of domestic animals, even though the structural differences between those breeds may be greater than exist between many wild species. Different breeds of pigeons differ from each other in external aspect and in osteological and other anatomical characters far more than many closely allied species. And yet there is not known to be any tendency to sterility in the crossing of the most widely different breeds. This difference between wild species and domestic breeds has often been alleged as an objection to the theory of evolution in general, since it has been claimed to show that a species must be due to some cause radically distinct from the occasional variations, accumulated and intensified by artificial selection, to which breeds of domestic animals owe their origin. It is probable that the true interpretation of the mutual sterility of species is found in the views of Romanes and Gulick. If a variation, useful in itself, and therefore fitted to constitute the basis of a new species under the operation of natural selection, is correlated with such variation in the reproductive organs as renders those individuals in greater or less degree incapable

of union with other individuals of the species, then that variation will not be in danger of disappearing by successive dilution as the result of promiscuous crossing with individuals not possessing the variation in question. On the other hand, a useful variation not thus correlated with changes in the reproductive system leading to sterility in crossing, will be liable to disappear by promiscuous crossing before it can be fixed by natural selection. According to these views, the characters which have been seized upon by natural selection, and have been made the basis for the evolution of new species, have been precisely those characters which were correlated with variations in the reproductive system rendering their possessors in greater or less degree incapable of crossing with other individuals of the species. This principle of "physiological selection" seems to offer an intelligible explanation of the prevalent fact of mutual sterility between individuals of different species, and it is obvious that the action of natural selection must be greatly aided by such physiological isolation. The supposition which is at the basis of this doctrine, namely, that very slight variations in the general structure may be correlated with such modifications of the reproductive system as will involve the result of mutual sterility, is in itself altogether probable. It is well known that the reproductive system is more susceptible than any other part of the organization to modifications dependent upon slight changes in the environment and mode of life. Very slight changes often suffice to render individuals altogether incapable

of reproduction, and it is easy to believe that very slight differences in the general organization of different individuals of a species may be correlated with such differences in the reproductive system as will involve a greater or less degree of mutual sterility.

A fifth objection to the adequacy of natural selection, in the absence of determinate variation, is found in the present views in regard to the length of geological time. Darwin was in geology a disciple of Lyell, the great leader of the uniformitarian school. As we have already seen,* that school of geologists regarded all geological changes as slow, and demanded well-nigh an eternity for the history of the earth. The new school of geology, which has displaced alike the old uniformitarianism and the older catastrophism, recognizes that, while some geological changes are slow, others are rapid. The question of the age of the earth has been studied by physicists as well as by geologists; and, in general, the physicists who have reasoned on the basis of thermodynamic laws in regard to the process of the cooling of the globe have reached the result that the age of the earth must be very much less than was supposed by Lyell and the uniformitarian geologists. While the geologists of to-day by no means implicitly accept the definite numerical statements in regard to the age of the earth which have been offered by some eminent physicists, it is undoubtedly true that geological thought has been largely influenced by the views of physicists. Charles Darwin, who was prima-

* Page 157.

rily a biologist, secondarily a geologist, estimated the time that has elapsed since the condensation of the ocean upon the cooling surface of the globe as 200,000,000 years. George Darwin, who is primarily a physicist, secondarily a geologist, estimates the age of the earth since its molten condition as only 57,000,000 years. The difference of opinion between father and son is somewhat representative of the difference between two generations of geologists. It is not unlikely that the latter estimate is too small, and that the pendulum must oscillate again and again before it comes to rest. Now it is obvious that the evolution of the vast multitude of species that have existed, solely by the agency of natural selection acting upon utterly indeterminate variations, must have been a slow process. It is indeed an important and valuable suggestion in this connection, that forms of life were much more plastic in earlier than in later geological time.* When life was just emerging from the primitive condition of unicellular simplicity, the differentiation of new sub-kingdoms may have been accomplished more rapidly than the evolution of new species at a later date. As the generations multiply, the force of heredity is strengthened. The centripetal force increases, the centrifugal force decreases. But, however much of weight may be given to this consideration, the conclusion remains that, in the absence of determinate varia-

* This idea was set forth by Professor H. W. Conn, of Wesleyan University, in an article published in the *American Naturalist* in 1886. See Conn, *The Living World*, p. 178. Adam Sedgwick, in his address before the Biological Section of the British Association in 1899, formulated the doctrine in the striking phrase, "The Evolution of Heredity." See *Nature*, vol. lx, p. 509.

tion, evolution must have required an immense amount of time.

While our knowledge is altogether inadequate to enable us to give any definite estimate of the time necessary for such evolution, one cannot avoid feeling at least a strong suspicion that such a process of evolution would be too slow to achieve the result in the moderate duration of a few tens of millions of years, to which we seem now to be restricted. If we can assume that causes of determinate variation exist, it is obvious that the process of evolution may have gone on much more rapidly.

It seems, on the whole, probable, that determinate variation has occurred. In all probability acquired variations are in some degree inherited; and, if this be true, the direct influence of environment, as assumed by Saint Hilaire, and the indirect influence of environment, as assumed by Lamarck, must both be recognized as true causes of determinate variation. And, in the density of our ignorance in regard to the causes alike of heredity and of variation, we certainly cannot deny the possibility that determinate variation may take place as the result of causes to us unknown.

A word should be said in regard to another agency in evolution, which is far less important indeed than natural selection, but which has probably had some effect. I refer to the principle which Darwin calls "sexual selection."* In order that a variation possessed by certain individuals should be preserved and

* Darwin, *The Descent of Man, and Selection in relation to Sex.*

intensified, it is not necessary that the individuals which do not possess that variation should be exterminated. It is sufficient that they should be prevented from propagating. If a breeder of domestic animals desires to develop any particular quality in his stock, he does it, as we have seen, by selective breeding. He breeds from those individuals in his herd which already possess the desired character in the highest degree. But it is not necessary that he should slaughter all the rest of his herd. It is sufficient that he should shut them up, and prevent them from breeding. So it may be assumed that, in a state of nature, a selection of certain individuals to propagate would be as real an evolutionary force as a selection of certain individuals to survive. It is a common belief with those who have never studied the life of animals, that, in a state of nature, the great majority of adult individuals pair and leave offspring. Darwin has shown, however, that there is much reason to believe this popular impression to be erroneous. He has shown that it is probable that large numbers of individuals that survive to maturity are prevented from propagating. In many species, the possession of the females is a matter that is decided by conflict among the males, and fierce duels are fought between rivals. In many species, peculiar weapons are developed by the males for use in these combats; and in some cases the relation of these weapons to the process of reproduction is the more obvious by reason of the fact that the weapons are borne only in the breeding season. In most species of deer, the antlers are

developed only in the male, and are shed periodically, being annually renewed at the breeding season. So it is, in most species of salmon, with the hooked jaw, which constitutes a very curious weapon in the male. In other species, the possession of the females is secured by a sort of courtship. Every one has observed, in the case of many of our common birds, the males endeavoring to attract the attention of the females by attitudes and actions adapted to display in the most attractive way the beauty of their plumage. In some cases the charm of plumage and of attitude is supplemented by melody of voice. It seems probable that Darwin is right in attributing to sexual selection the development of those weapons of offense and defense which are borne only by males, and the brilliant plumage which is so frequent a characteristic of male birds. The dull and inconspicuous colors often worn by female birds of those species in which the males are brilliantly colored, are doubtless to be understood as protective colors, rendering the bird less conspicuous while sitting upon her eggs.

It seems certain that the principle of sexual selection is an agency of considerable importance in preserving from degeneration the character of the human species. It is obvious that marked physical defects, diseases that are repulsive, contagious, or liable to be inherited, disgraceful immorality, and general shiftlessness and forcelessness such as to incapacitate one for self-support, render persons undesirable as partners in marriage. It is an important consideration, as

regards the future of the human race, that the effect of Christian civilization is substantially to abolish the action of natural selection between individuals of the race. In the pre-human and in the earlier human stages of our ancestry, natural selection was unquestionably a most important force. The weak and puny were left to starve, or were actively destroyed. And, when civilization had advanced so far that intentional destruction of offspring was discountenanced, the lack of medical skill and sanitary science generally allowed weak and puny children to fall early victims to disease. While thus those individuals that were physically inferior were exterminated, Draconian codes of justice destroyed those individuals whose moral character was not up to the standard required by the moral sense of the tribe. It is obvious, however, that this action of natural selection has practically ceased in the life of civilized man. Public sanitation and medical skill preserve to maturity those whose physical weaknesses or defects render them most unfit to survive, and the milder sentiment of modern times has almost abolished the death penalty even in the case of atrocious criminals. The operation of natural selection continues a little longer in the relations of different nations or tribes than in the relations of individuals of the same nation or tribe. The disappearance of the American Indians from most of the territory of the United States has been an exhibition of the effect of a pretty relentless natural selection. But, as human life becomes more completely dominated by that senti-

ment of universal brotherhood which characterizes a Christian civilization, it is evident that the operation of natural selection within the human race must entirely cease. Society must demand for its own protection, when the safeguard of natural selection is lost, that sexual selection be exercised more strictly and strenuously than in former times. The marriage of persons in any marked degree physically abnormal or defective must be interdicted by public opinion, supplemented, if necessary, by legislation; and the propagation of a criminal class must be checked by the adoption of the principle of the indefinite sentence even for petty crimes. The principle of the indefinite sentence has been advocated by many of the most enlightened sociologists of our time on entirely different grounds, but it is evident that their arguments find strong reinforcement in biological science. Not only the negative, but also the positive, application of the principle of sexual selection is important for the maintenance and advancement of the character of the race. The social and economic conditions that tend to abstinence from marriage, late marriages, and childless marriages on the part of the better classes of the population, must be regarded with grave anxiety.*

The Origin of Life

From the question of the origin of particular species we pass to the consideration of the question of the origin of life itself, for obviously the doctrine of bio-

* Pearson, *Grammar of Science*, 2d edition, p. 466.

logical evolution is not complete unless it can include in its scope the origin of the earliest organisms, which must be supposed to have been the ancestors of all subsequent life. If the doctrine of evolution in astronomy and geology gives us a continuous development of the inorganic world from the initial condition of a nebula to the dawn of life, and if the doctrine of evolution in biology gives us a continuous development of the organic world from the dawn of life to the flora and fauna of to-day, there is still required for the completion of the idea of the unity of nature the recognition of a natural process of evolution whereby non-living matter becomes living.

At the time when the publication of Darwin's "Origin of Species" opened the modern phase of the discussion of biological evolution, the question of the spontaneous generation of certain organisms was a subject of earnest investigation and bitter controversy; and it was then clearly recognized that a theory of the evolution of life from non-living matter was required for the completion of the general doctrine of evolution.

It is a curious fact that, though in general the prejudices of ignorance have been adverse to evolutionary ideas, those prejudices have been in favor of spontaneous generation. There are two reasons for the prevalence of a crude and unintelligent belief in spontaneous generation. One of these is the fact that the larval forms of many animals are so very unlike the adult forms that the relationship between the two may

long remain unsuspected. When a piece of putrefying meat is seen to be swarming with maggots, of course people ignorant of zoology do not suspect that the maggots are young flies. They look so entirely different from flies that their relationship is easily overlooked. The other reason for a popular belief in spontaneous generation is the fact that in many cases organisms appear in situations where it seems very difficult to account for their presence unless they can be supposed to have been spontaneously generated. Insect larvæ are found in fruits that appear externally sound, the slight wound where the egg of the creature was introduced having been so completely healed as to be unrecognizable. Parasitic organisms are found in animals, not merely in the alimentary canal, where it is comparatively easy to understand the method of their introduction, but enveloped in the tissues of various organs, as the lung, the heart, the brain, or the eye. In some of those cases the difficulty of accounting for the presence of the parasites is so great that it is no wonder that people have been led to believe that the organisms are spontaneously generated in the situations in which they are found.

Indeed, so strongly was the unscientific mind in former ages possessed by the idea of the spontaneous generation of new life out of the decay of old life that even the normal processes of vegetable reproduction were misinterpreted as cases of spontaneous generation. It was, for instance, the common belief that a seed buried in the ground died, and from its death was

evolved the new life of the growing plant. In one of the most touching and beautiful of all the discourses of Jesus, we find a figurative passage based upon this popular misinterpretation of the facts regarding the germination of seeds:—"Except a corn of wheat fall into the ground and die, it abideth alone; but, if it die, it bringeth forth much fruit."* Of course we are in no wise disturbed by the recognition of the scientific error involved in this figure. It was not the mission of Jesus to lecture on vegetable physiology. But the passage strikingly illustrates the prevalence of the popular belief in the spontaneous generation of new life out of the decay of old life.

But, however tempting might be the belief in spontaneous generation, as affording an easy explanation of the presence of organisms in situations where it was difficult otherwise to account for them, such a belief could not persist in the face of scientific investigation. The very beginning of scientific investigation of the subject at once disposed of many of the supposed cases of spontaneous generation.† The first serious attempt at the investigation of supposed cases of spontaneous generation was made by an Italian named Redi, whose results were published in 1668. He investigated the origin of the maggots which commonly appear in putrefying meat. He tried the very simple experiment of putting a piece of meat in a jar and tying a sheet of

* John, xii, 24.

† An admirably clear and interesting history of the investigations resulting in the disproof of spontaneous generation is given in Huxley's address on *Biogenesis and Abiogenesis*, included in his *Discourses Biological and Geological.*

gauze over the mouth of the jar. Plenty of flies buzzed around the jar, but the meshes of the gauze were too fine for them to get through; so the flies could not get to the meat, and of course no maggots appeared in the meat. But it was observed that some of the flies laid eggs on the gauze, and the development of those eggs was watched. It was found, of course, that in due season maggots were hatched from the eggs, and so the spontaneous generation of maggots was disposed of at once and forever.

While it was thus easily proved in the case of comparatively large and conspicuous animals that they originated by normal processes of reproduction, and not by spontaneous generation, the proof of such a conclusion was obviously less easy in the case of organisms of extreme minuteness. Two hundred years after Redi's time, when the controversy in regard to evolution was raging with fiercest intensity, the question of spontaneous generation had become limited to organisms so minute that their existence was unknown and unsuspected in Redi's time and for generations thereafter. At the time of the publication of "The Origin of Species," the only organisms which any scientific man supposed to be spontaneously generated were bacteria. These are organisms of extreme minuteness, unicellular, and so simple in structure as to be destitute of any conspicuous nucleus. In the common classification which somewhat arbitrarily distributes the lower and simpler organisms between the vegetable and the animal kingdoms, these organisms are referred

to the vegetable kingdom. It has long been well known that, whenever a liquid containing some of the more complex organic compounds, as, for instance, an infusion of meat or cheese or hay, is exposed to the air for a time at a moderately warm temperature, it undergoes a chemical change revealed by those extremely disagreeable odors which we call the odors of putrefaction, and, if examined under a high power of the microscope, it is found to be swarming with bacteria. These two phenomena, namely, the peculiar form of chemical decomposition which we call putrefaction, and the appearance of swarms of certain species of bacteria, are always found to accompany each other. Their uniform relation of coexistence suggests that they stand to each other also in a causal relation; but which is cause, and which is effect? Does the chemical change of putrefaction afford the necessary condition for the spontaneous generation of bacteria? or is the multiplication of bacteria the cause of the chemical change? That is the question which was hotly discussed in the middle of the nineteenth century.

Of course there is no doubt about the matter now. The researches of Pasteur and others have conclusively proved that the bacteria owe their existence to normal processes of reproduction, and that the putrefaction of the liquids is the effect and not the cause of the multiplication of the bacteria. It is curious how completely Redi's classical experiment, by which he disproved the spontaneous generation of maggots, was the type of the more refined and elaborate experiments by which

the spontaneous generation of bacteria was disproved. A very simple experiment of the sort may be made as follows:—If we put into a flask a small quantity of some putrescible infusion, stuff the neck of the flask with a plug of cotton wool, boil the liquid for two or three hours, and then leave the flask for some days exposed to the atmosphere under ordinary conditions of temperature; in the majority of cases no bacteria will appear in the liquid, and the liquid will not undergo that form of chemical change which is called putrefaction. Whatever living organisms may have existed in the liquid at the commencement of the experiment, will have been killed by the boiling; and the introduction of organisms or spores of organisms from without will have been prevented by the plug of cotton wool. The plug of cotton wool, in fact, serves precisely the same purpose as the sheet of gauze in Redi's experiment, only it is practically a net of finer meshes adapted to catch more minute objects. The parallelism between the experiment of the seventeenth century and those of the nineteenth may be carried a step further. As Redi found the eggs of flies on his sheet of gauze, and hatched them into maggots, so we may introduce into the liquid upon which we are experimenting some of the cotton with which the flask is plugged in the experiment just described, and the result will be that the liquid will quickly swarm with bacteria, and undergo the consequent putrefactive change. Germs which had been floating in the air have been caught in the cotton wool.

I have said that, under the conditions of the experiment above described, the liquid will ordinarily remain for an indefinite time free from bacteria and free from putrefaction; but in some cases, if the experiment is carried on precisely as has been described, bacteria will appear, and putrefaction will commence. For a long time these conflicting results at the hands of different experimenters, under what seemed essentially similar conditions, were very puzzling indeed. It appeared, in general, that the higher the temperature to which the liquids were subjected and the longer the time of their exposure, the less likely were bacteria to appear. The conflicting results are now perfectly intelligible. We know that the appearance of bacteria in experiments of the general class under discussion was due in some cases to the blunders of careless or incompetent experimenters. But in other cases the appearance of bacteria was due to the fact that the spores of many species of bacteria are much more tenacious of life than are the organisms in their active condition. Such spores may be killed by the use of extremely high temperatures; or the organisms into which they develop may be killed by prolonged boiling or by boiling repeated at intervals.

A very important side light was thrown upon the question of spontaneous generation by the investigations of Tyndall, the English physicist. He showed in his experiments that, if a beam of intense light, as from a powerful electric lamp, passes through a chamber filled with air in which are floating solid or liquid

particles of extreme minuteness, the path of the beam will be manifest by a pale blue radiance like the azure of the sky, the result of the selective scattering of the rays of shortest wave-lengths from the surfaces of these minute particles. The blue of the sky, in fact, is due precisely to such a selective reflection of sunlight from minute solid or liquid particles floating in the atmosphere. On the other hand, Tyndall showed that, if a strong beam of light passes through a chamber filled with air entirely destitute of solid or liquid particles, the path of the beam will not be revealed. There being nothing to reflect the light, that part of the chamber through which the beam is passing will have the same utter blackness as the rest. It was thus shown to be possible by optical means to determine whether a portion of air does or does not contain minute solid or liquid particles. Now, it was further shown that putrescible liquids can be exposed for indefinite periods of time to air that is destitute of floating particles, without becoming infected by bacteria and without any putrefactive change; while the same liquids, if exposed to air in which the optical test reveals the presence of solid particles, quickly become infected. It was thus shown that under ordinary conditions atmospheric air contains countless multitudes of solid particles, some of which are bacteria or spores of bacteria.

It would lead us too far away from the subject which we have in hand, if we should undertake to speak of the results of modern bacteriological study. The value of the contributions which bacteriology has made

to hygiene and medicine is absolutely incalculable. The knowledge of the bacterial origin of many diseases prepares the way for the discovery of means of prevention and of cure. The diffusion of infectious diseases by means of contamination of water and milk we have learned effectively to prevent. Antiseptic surgery performs with little peril operations involving the opening of internal parts of the body, which in former times would have been almost certainly fatal. But of course we are at present concerned only with the bearing of bacteriological investigation upon the question of spontaneous generation.

About the same time that the question of spontaneous generation of bacteria was eagerly discussed, there was a hope of some light on the question of the origin of life from another direction. Those same years, just after the middle of the nineteenth century, were marked by the beginning of activity in the exploration of the depths of the sea and in the investigation of the life of the abyssal zone. In those dark abysses, where the conditions might reasonably be supposed to have remained substantially unchanged for countless ages, it was thought that we might well expect to find still surviving representatives of the earliest forms of life; and, when, in a sample of ooze from the ocean bottom which was under microscopic examination, there was seen a vague, shapeless, slimy something, it was taken for granted that the earliest and simplest type of life had been discovered—a diffused mass of unorganized protoplasm. Professor

Huxley bestowed upon the newly discovered creature, thus hailed as the representative of the ancestral form of all life, the name *Bathybius*. Bathybius, however, was soon pretty thoroughly discredited. It turned out to be in the main simply a slimy precipitate of gypsum, resulting from the action of the strong alcohol used as a preservative material upon the salts in solution in the sea-water. It may have consisted in part of the debris of various organisms that had gone to pieces. Evidently Bathybius could throw no light upon the nature of the earliest organisms and the problem of the origin of life. Huxley frankly acknowledged that Bathybius was a mistake;* and that, I believe, is the judgment of nearly all zoologists. It may be remarked incidentally that the failure to find at the bottom of the sea samples of the primitive unorganized protoplasm from which life might be supposed to have started, was not the only disappointment connected with the exploration of the ocean bottom. In general, the expectation of finding there extremely archaic forms which would throw light upon the early stages of the evolution of sub-kingdoms and classes was disappointed. The life of the abysses seems for the most part not to be of very ancient types, but to consist chiefly of forms whose ancestors migrated into that region of darkness from other bathymetric zones. Reference has already been made† to the interesting suggestion of Morris and Brooks, that life probably commenced, and most of the main types of life were

* *Nature*, vol. xx, p. 405.

† Page 205.

evolved, not at the bottom, but at the surface, of the sea.

It must therefore be confessed that we have no definite knowledge in regard to the origin of life. The belief in the evolutionary origin of life has absolutely nothing in its support except the force of general analogies; and the estimate that will be put by different thinkers upon the value of such analogies depends very largely upon subjective conditions. Conclusions that rest only on analogy must be held tentatively and not dogmatically. Yet I believe that a qualified and provisional acceptance of the conclusions to which analogy points is more philosophical than their rejection. When we trace a continuous evolution from the nebula to the dawn of life, and again a continuous evolution from the dawn of life to the varied flora and fauna of to-day, crowned with glory in the appearance of man himself, we can hardly fail to accept the suggestion that the transition from the lifeless to the living was itself a process of evolution. Though the supposed instances of spontaneous generation all resolve themselves into errors in experimentation, though Bathybius proves to be only precipitated gypsum, though the power of chemical synthesis, in spite of the vast progress it has made, stops far short of the complexity of protoplasm, though we must confess ourselves unable to imagine a hypothesis for the origin of that complex apparatus which the microscope has revealed to us in the infinitesimal laboratory of the cell, are we not compelled to believe that the law of continuity has not been broken,

and that at least a reasonable hypothesis in regard to the method of transition from the lifeless to the living may yet be within reach of human discovery? That, I believe, is to-day the attitude of most scientific men; and that faith in the evolutionary origin of life, provided it be held tentatively and never asserted dogmatically, seems to me amply justified. Whether investigation is destined in the near future to throw any additional light upon the question of the origin of life, it were vain to prophesy. It seems not impossible that chemistry may throw some light upon the origin of the characteristic materials of the living body. It is a significant fact that the phrase, "chemistry of the carbon compounds," has well-nigh taken the place of the old phrase, "organic chemistry," as one after another of the compounds formerly supposed to be capable of production only in the living laboratory of the vegetable or animal cell has been produced by artificial synthesis. It is a long history of progress from Wöhler's synthesis of urea in 1828—the first breach effected in the wall which partitioned off organic from inorganic chemistry —to Schützenberger's synthesis of peptone in 1891. Surely we must believe the end is not yet in the knowledge of the chemical materials of the living body and their possible origin. A cell, indeed, is not merely a minute quantity of protoplasm, but an elaborate organism. Yet the nuclear apparatus in different cells exists in very different stages of development, and it is not impossible that the comparative study of the simplest forms of cell structure may throw some light

upon the problem of the origin of that wondrous mechanism. There seems no reason to expect success in any experiments in the direction of spontaneous generation. The evolution of protoplasm and of cells may have occupied long periods of time, and there is little probability that protoplasm and cells can be manufactured under the conditions of laboratory experimentation.* Though we must confess ourselves completely ignorant of the method of the origin of life, yet, if we are to choose between the two alternatives of a belief that the process of the origin of life, if known, would be found to be a part of a continuous system of evolution, and a belief that that process is utterly out of relation with all other known facts of the universe, the scientific mind can hardly hesitate to choose the former.

THEOLOGICAL BEARINGS OF EVOLUTION†

We must now give our attention to the effect of the theory of evolution upon religious belief. We have seen that the first phase of the evolution theory developed in modern times was the astronomical phase—the nebular theory. The announcement of that theory did not occasion any very violent theological controversy. Some theologians indeed declared, in opposition to the nebular theory, that, according to the Bible, "the worlds were framed by the word of God,"‡ and

* Pearson, *The Grammar of Science*, 2d edition, p. 349.

† Gray, *Darwiniana;* Le Conte, *Evolution, and Its Relation to Religious Thought;* McCosh, *The Religious Aspect of Evolution;* Schurman, *The Ethical Import of Darwinism;* Drummond, *The Ascent of Man;* Tyler, *The Whence and the Whither of Man;* Fiske, *Through Nature to God;* Smyth, *Through Science to Faith.*

‡ Hebrews, xi, 3.

not by the law of gravitation. Those theologians forgot that the law of gravitation, like every other law of nature, is the word of God. Nor did the rise of evolutionary doctrine in geology excite any violent theological opposition. Geology, indeed, was bitterly opposed in its earlier history, not because it was supposed to be contradictory of theistic belief, or of Christian belief in general, but because it was supposed to contradict the Scripture text in regard to the antiquity of the earth and man; and, with the abandonment of the dogma of inerrancy of Scripture, the conflict between theology and geology is at an end.

But the publication of Darwin's "Origin of Species" marked the beginning of the most intense theologico-scientific controversy of our time. The younger generation of students to-day can hardly appreciate the agonies of terror with which the doctrine of evolution was regarded by many Christians three or four decades ago, and the intense bitterness with which the theory and its advocates were denounced. It is true that there were some men then sagacious enough to recognize that the acceptance of evolution would not destroy theistic or Christian belief. Very soon after the publication of Darwin's book, Asa Gray, Professor of Botany in Harvard University, and, in my judgment, the most profoundly philosophic naturalist our country has ever produced, wrote an essay entitled, "Natural Selection Not Inconsistent with Natural Theology."* The bearing of evolution upon the theistic question is

* *Atlantic Monthly*, 1860; *Darwiniana*, p. 87.

treated in that essay in so masterly a fashion that scarcely anything more on that point needs to be said to-day. While there were Christian men of science who accepted evolution and found it perfectly consistent with Christian faith, there were men more distinctly recognized as theologians who took the same philosophical view. Prominent among these was James McCosh, then President of Princeton University. Yet it was a wide-spread belief, both within and without the Christian church, that, if a belief in organic evolution should be generally accepted, Christianity was doomed to extinction. Of course all that is changed. An irenic era has followed the period of conflict. The curriculum of a theological seminary is hardly regarded as complete to-day without a course of lectures on the consistency of evolution with theistic philosophy. In this peaceful era it is easily possible to underrate the effects which the theory of evolution must produce upon theological belief. Justin McCarthy, in his brilliant, but sometimes rather flippant, "History of Our Own Times," refers to the violent controversy that arose after the publication of Darwin's book, and records his opinion that the controversy was entirely unnecessary, since "Darwin's theory might be accepted by the most orthodox believer without the firmness of his faith moulting a feather." I suspect, however, that the question whether a man was compelled to moult some feathers of his theological plumage or not, would depend considerably upon what might have been the precise character of the plumage

which he wore before. It is certain that some theological beliefs which were very commonly held before the beginning of the epoch of evolutionary thought must be very seriously modified.

It is not, indeed, necessary to spend any time in proving that evolution is not atheistic.* Ages ago, before modern science was dreamed of, Saint Augustine distinctly taught that the theological idea of creation included mediate as well as immediate creation—creation through the operation of secondary causes, as well as creation by direct and processless fiat. For many generations the communicants of the Church of England, and many other English-speaking worshipers, have joined in the language of the general thanksgiving, in which God is praised "for our creation, preservation, and for all the blessings of this life," though I suppose no one of those worshipers has imagined that he himself was brought into existence by a direct fiat of God without any process of secondary causation.

The theory of evolution is indeed the implacable foe of that sort of theistic philosophy which has been happily satirized in the phrase, "the carpenter God." The evolutionist cannot believe in a God who once in the remote past built a universe, and who now manipulates it from without. The evolutionist cannot accept the theistic philosophy which regards nature in its ordinary course as self-acting, and recognizes the presence and the agency of God only in unusual and startling

* See fuller discussion of the personality of God and of his relation to the universe in Part II.

events. The God who is seen only in the supposed gaps in the continuity of nature, is a God in whom the evolutionist can have no faith. In answer to the question of the Catechism, "Who made you?" a smart boy is said to have answered, "God made me so big"—measuring off on his arm about what he supposed to be his stature at the time of birth,—"and I grew the rest myself." Of all that kind of theistic philosophy evolution is the implacable foe. But evolution is perfectly in harmony with the faith of ancient Hebrew bards who saw God's presence in all the beauty and majesty of nature, who heard God's voice in every tone of nature's music, who knew no difference between the natural and the supernatural in a world which was everywhere full of God. The evolutionist can join in the worship of One

> "Whose dwelling is the light of setting suns,
> And the round ocean, and the living air,
> And the blue sky, and in the mind of man:"—

a God in whom "we live and move and have our being."

Nor need we now spend any time in discussing the conflict or the harmony between evolution, and the second and the third chapter of Genesis. The relation of the early chapters of Genesis to scientific facts and theories has been already sufficiently discussed;* and we have seen that the supposed necessity of reconciliation between scientific beliefs and the Scripture text arose only from the dogma of the inerrancy of the Bible, which forms no part of the catholic faith of the church,

---

* Page 81.

and whose influence has been always pernicious. Of course the evolutionist does not believe in the manufacture of Adam out of the dust of the ground, nor in the manufacture of Eve out of a rib, nor in the historic character of the story of Eden in general. How far the story of Eden is conscious allegory, and how far it is legend erroneously supposed to be history, is a question of purely literary criticism.

It is in the department of anthropology that our theological beliefs are most seriously affected by the theory of evolution. There is no reasonable doubt that man himself, at least as regards his physical nature, is a product of evolution. Man is an animal, a member of the sub-kingdom Vertebrata, the class Mammalia, the order Primates. Zoological classification has the same meaning in its application to man as in regard to other organisms. The reference of man to a sub-kingdom or class or order expresses the degree of his structural resemblance to other animals. The evidence of evolution that is afforded by homologies of structure is the same in regard to man as in regard to other vertebrates. Those embryological laws which are so strongly indicative of evolution may be amply illustrated from the body of man. In the human embryo, the aorta branches into a series of arches homologous with the branchial arches of the fish, and the pharynx develops a series of pouches homologous with the gill pouches of a shark.* Man's body is a perfect museum of rudimentary organs, from the rudimentary muscles

* See page 184.

that can no longer prick up the ears, to the rudimentary muscles that can no longer wag the rudimentary tail; from the rudimentary third eyelid which can no longer brush dust from the eyeball, to the rudimentary intestinal cæcum, whose only known function is appendicitis. It is often said that there are no intermediate links between man and any ape-like form. It is indeed true that we cannot trace a series of fine gradations between man and any ape-like form, but it is not true that we have no evidence of gradation. Among the very few human skulls which are certainly or probably of Quaternary age, several bear a character more simian than is typical of any existing race. In those skulls, the low, retreating forehead, and the very strongly developed superciliary ridges, give to the skull an extraordinarily simian aspect. So long as the Neanderthal skull, the earliest discovered of this type, stood alone, it could reasonably be supposed to be an individual exception, abnormal or even pathological. But it is simply incredible that so large a proportion of the known fossil skulls as exhibit characters similar to those of the Neanderthal skull can be merely individual exceptions. The fragment of a skull found a few years ago in Java presents the simian characters in decidedly greater degree even than the Neanderthal skull. So strongly simian, indeed, is the aspect of the Java skull, that some anatomists and paleontologists have considered it the most man-like of apes,* rather

* It was described by its discoverer under the name *Pithecanthropus erectus*. See page 77.

than, as seems more just, the most ape-like of men. A skull in regard to which able anatomists can dispute whether it is human or simian is certainly in some degree an answer to the demand for the production of the "missing link." The facts seem to render it well-nigh certain that in Quaternary time there was developed a race of men more simian in type than even the lowest race of savages now existing, and ranging from the East Indian Archipelago to western Europe. There is indeed a wide gap between even the Java skull and that of the highest of the anthropoid apes. As nearly as can be estimated in the fragmentary condition of the Java skull, its cranial capacity must have been not much less than twice that of the gorilla, though the weight of the gorilla is considerably greater than that of man.* It is, of course, by no means certain that any very fine gradations between man and

Fig. 12.—Upper surface of skull of Pithecanthropus erectus. From Keane's "Ethnology."

* Dubois estimates the cranial capacity of *Pithecanthropus* as somewhat more than 900 cubic centimeters. *Smithsonian Report*, 1898, p. 449. The cranial capacity of adult gorillas varies from about 400 to about 600 cubic centimeters. The capacity of normal adult human skulls varies from about 1,000 to about 1,800 cubic centimeters.

his simian ancestry ever existed. We have already seen* that there is reason to believe that the very large variations which occasionally occur have played a considerable rôle in the history of evolution, and it is not at all unlikely that man himself may have originated

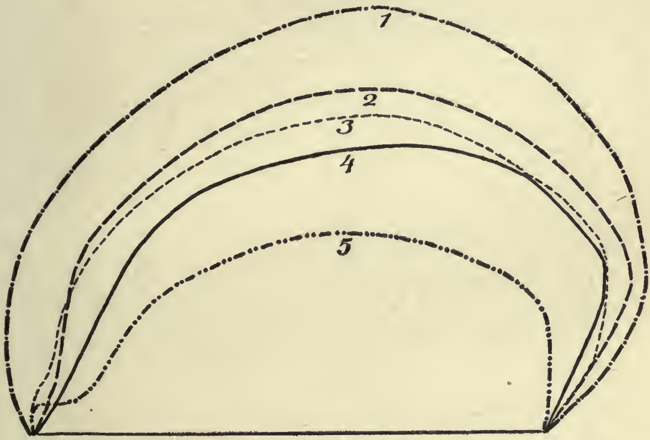

FIG. 13.—Profiles of human and simian skulls. The skulls are all reduced to the same length, and the base line extends from the glabella (at the left of the figure) to the posterior margin of the foramen magnum (at the right). 1, Papuan (modern); 2, fossil skull from Spy, in Belgium ("Spy, No. II"); 3, fossil skull from Neanderthal; 4, Pithecanthropus erectus; 5, chimpanzee. Taken (with modifications) from Le Conte's "Elements of Geology."

by the sudden appearance of variations of an extraordinary character. The fact should, moreover, be considered, that there has been as yet no very thorough geological exploration in any region which can reasonably be supposed to be the cradle of the human race.

* Page 224.

That man did not originate in western Europe is substantially certain. From this point of view it is an exceedingly significant fact that the most ape-like human skull thus far discovered has been found in the East Indian Archipelago, the land of the orang and the gibbon.

Assuming, then, that man is a product of evolution, what modifications must we make in theological beliefs concerning man? In the first place, it may be said that the effect of the acceptance of evolution is simply to show that the origin of the earliest human beings was exactly the same as that of their successors. In regard to all subsequent generations of human beings, there is no doubt whatever that each individual has originated, as regards his physical organism, by a process of secondary causation which is pretty well understood. But what is the origin of the soul or spirit—of the something, however it may be named, assumed as the substratum of thought and feeling and will? In all the Christian centuries, two different views have been maintained among theologians in regard to the origin of the soul of each individual. The doctrine which, at least in modern times, has been generally considered the most strictly orthodox, is the doctrine of creationism. According to this view, while the body of the individual is evolved by a well-known process of secondary causation, the soul of every individual is created by a direct fiat of the Deity. The soul is in its origin thus independent of the body with which it is associated; but, by the decree of the Creator, it is

mysteriously united with the body, at some time before, at, or after birth, and remains united to the body during this earthly life. As the soul is independent of the body in its nature and origin, it may be supposed to survive after the dissolution of the body. The other view, which has been maintained by theologians of repute and influence in every age of the church, is the doctrine of traducianism. It maintains that the individual inherits not simply his physical organism, but also his spiritual nature, from his parents. Some of the older traducianists conceived the doctrine in such form as to involve a dormant pre-existence of individual souls from the beginning of human history. According to this phase of the traducianist doctrine, the souls of the whole human race came into existence at the time of the creation of Adam, were stored up in his body, and have been gradually distributed in subsequent generations. A theory so grotesque it is needless to discuss. Enough to say that no such doctrine can breathe the atmosphere of the twentieth century. The only form in which the traducianist doctrine can be held at present, is that of an actual procreation of the soul—a procreation of that essence, whatever it may be, in which inhere the spiritual faculties of human nature. Thus conceived, I believe that traducianism leads by a logical necessity to some sort of monistic theory of human nature. Every conception we can form of procreation, generation, or reproduction, in any mode whatever, involves the idea of the division of the substance of the parent. It is a part of the parent that is

converted into the new organism, in every form of reproduction, alike in the animal and in the vegetable kingdom; and any process analogous to procreation in the case of an indivisible unit, such as the human soul has generally been assumed to be by those who have held the dualistic view, seems utterly unthinkable.

The question of the origin of man is therefore closely connected with the metaphysical question of the unity or plurality of essence in human nature. The fundamental fact which any theory of human nature is bound to recognize is that the experience of thought, feeling, and will, which constitutes the conscious life of man, is in some way connected with the form of organized matter which we call the human body, and especially with the chief ganglionic center of the nervous system, the brain. Every physiologist believes that every state of consciousness is correlated with some definite molecular change in the matter of the nervous system, in such sense that a being possessed of sufficient intelligence could infer the character of the state of consciousness from the knowledge of the molecular change, or infer the molecular change from the knowledge of the state of consciousness.

Some psychologists and philosophers have indeed denied that there is evidence of such a correlation. I quote from a text-book of psychology, which has been widely used in our schools and colleges:* "We grant that the landscape which we see must first be pictured

* Porter, *Elements of Intellectual Science*, p. 19.

on the retina. But what change or affection of the material organism occurs when the soul, at the sight of this landscape, images another like it, calls up by memory a similar scene, or by creative acts of its own constructs picture after picture? or what bodily changes precede desire and disgust, hope and fear, at these memories and creations? No such changes have ever been discerned." That the cerebral changes which accompany the changing states of consciousness have not been discerned, is very certain. Men are not accustomed to do a large amount of thinking, with the roof of the skull removed, and with the brain placed under a microscope for the examination of its histological changes, or subjected to chemical reagents to detect the oxidations or other processes which may be going on in the minute laboratories of its cells. But that such changes are going on in connection with every process of thought or emotion is certain. When the mind becomes increasingly active, we have good reason to believe that an increased supply of blood goes to the brain, and an increased amount of chemical change takes place in that organ. The chemical changes are undoubtedly accompanied by histological changes.* The machinery is working vigorously, though the details of its working are beyond our view. It is true indeed that the induction of a correlation in detail between particular states of consciousness and particular changes in the brain goes far beyond the reach of actual or possible proof by observation or experiment.

---

* Page 140.

But this is no more than is true of the doctrine of conservation of energy and of the Newtonian law of gravitation. The broad inductions which are the most valuable results of scientific investigation, are based upon the indications of experience, but transcend the range of experience. The acceptance of "psycho-physical parallelism," as a generalization of the relations of two orders of phenomena, is amply justified,* whatever may be thought of the metaphysical doctrines which the phrase is often understood as implying.

But, however intimate may be the correlation between states of consciousness and cerebral changes, the two orders of phenomena are utterly disparate and incommensurable. The brain and nerves are matter, and their molecules are subject to the same physical and chemical laws as other material molecules. All cerebral changes must be assumed to conform to the law of conservation of energy.† In the last analysis, the cerebral changes which are correlated with states of consciousness are simply motions of certain portions of matter through certain distances in certain times. They are theoretically capable of being completely formulated in terms of mass and velocity. But a state of consciousness has no spatial relations whatever; and to speak of formulating a state of consciousness in terms of mass and velocity is absolute nonsense.

A philosophical theory of human nature must recognize, on the one hand, the correlation between states of consciousness and cerebral changes, and, on the

* Baldwin, *Development and Evolution*, p. 10.

† Page 139.

other, the disparateness and incommensurability of the two orders of phenomena.

The metaphysical theories which profess to formulate the mutual relations of the physical and the psychical in man may be classed under the four titles of materialism, spiritualism, dualism, and monism.*

Materialism assumes that the physical organism is the one real substance in which both orders of phenomena inhere. Psychical activities must be considered as functions of the brain. Whatever cannot be formulated in terms of physical change is repudiated, slurred over, or ignored. A characteristic expression of the position of extreme materialism is the statement of Karl Vogt:—"As contraction is the function of the muscles, and as the kidneys secrete urine, so, and in the same way, does the brain generate thoughts, movements, and feelings." If this language means anything, it seems to imply that thoughts and feelings are a form of matter or a form of motion. The two alternatives are equally absurd. Spiritualism is the exact contrary of materialism. "It claims that the so-called body has only a phenomenal existence; the body is but a series of phenomena that are indeed of a special order, but are phenomena of the reality called mind, and are to be referred to such reality as their sole ground."† While this mode of thought is satisfactory to a few metaphysicians, most men feel that it affords no ade-

* These words, all of which have been used by different writers with somewhat different meanings, are employed here in the senses in which they are defined by Professor Ladd, in his *Philosophy of Mind*, ch. ix, x.

† Ladd, *Philosophy of Mind*, p. 288.

quate recognition of the facts of experience. To regard the external universe as a mode of activity of the Divine Mind may be legitimate. But to make our bodies and material things in general phenomena of our own minds is felt by most men to be a contradiction of their inalienable belief in the objective reality of the universe. Dualism is the philosophy which is in general naively accepted by men of common sense who have studied neither science nor philosophy; and, in spite of all its difficulties, it is held by many of the most philosophical thinkers. Certainly the most obvious way of formulating the significance of the duality of phenomena presented in human experience is by the supposition of a duality of essence. Monism aims to recognize the duality of experience which lies at the foundation of dualism. It does not, like materialism, slur over the facts of subjective experience; nor does it, like spiritualism, seem to make the objective world an illusion—a creation of the mind itself. But the monist is impressed with the difficulty of the conception of the interaction of two entities distinct in nature and origin. Monism, accordingly, conceives the two orders of phenomena that constitute our dual life as inhering in a single essence. "The *ego* is not compounded of body and soul, but it is a determinate stage of evolution of being, which, contemplated from different standpoints, divides itself into bodily and spiritual being."*

* Wundt, *Vorlesungen über die Menschen- und Thierseele*, vol. i, p. 293. The sentence quoted stands as the motto of Romanes' essay on Monism (*Mind and Motion, and Monism*, p. 39).

Dualism and Monism

The belief has been somewhat generally entertained that all ethical and religious doctrines require as their logical basis a dualistic conception of human nature; and particularly that, unless man possesses a spirit altogether distinct from matter in nature and origin, there can be no such thing as moral responsibility, and no hope of immortality. In this belief men have been anxious to find, somewhere between the realm of inorganic matter and the realm of human life, a chasm so wide as to compel the admission of a distinct entity in human life utterly apart from matter. Under the influence of this line of thought, theologians have generally regarded with fear and aversion those scientific facts or theories which suggest the idea of a continuity through all grades of existence, from inorganic matter to man. The doctrine of the correlation of physical and vital forces, which we have considered in the discussion of the general doctrine of the conservation of energy,* has been looked upon with suspicion, as tending to destroy the line of demarcation between living and non-living matter. In the middle of the last century, when the question of the spontaneous generation of bacteria was being earnestly investigated, it was felt by many religious men that the establishment of spontaneous generation would overthrow all ethical and religious faith. From the same standpoint, the belief in the evolutionary origin of life, now held by many scientific men upon the more general ground of the analogies of nature,† seems as objectionable as the

* Page 136. † Page 249.

same belief when based upon the supposed result of experiment.

It is obvious that a belief in the evolutionary origin of man involves no absolute logical contradiction of the most orthodox dualism in philosophy and creationism in theology. Evolution logically demands only that the origin of the earliest human beings should be acknowledged to be the same as that of their successors. The dualist is perfectly at liberty to maintain that, in the case of the earliest human beings, as in the case of their successors, a body was developed by a process of evolution, and a spirit created by a fiat of Deity was united with that body when it had attained the suitable stage of development. There is, then, no logical contradiction between the doctrine of evolution and the most orthodox belief in regard to the nature and origin of that substratum wherein inhere the spiritual endowments of humanity.

Nevertheless I cannot escape the conviction that the tendency of evolutionary thought is decidedly towards monism; and I am inclined to believe that the longer a man has been a believer in evolution, and the more completely the cells and fibers of his cerebrum have grown into adjustment with that idea, or (substituting a psychological for a physiological expression of the fact) the more completely his ideas on other subjects have become correlated with the idea of evolution, the less likely is he to be satisfied with the conception of a spirit created in absolute independence of the evolution of the body, and, in some utterly inscrutable manner,

before, at, or after birth, attached to the body. The longer a man has been an evolutionist, the more incongruous appears the notion of an arbitrary conjunction of entities utterly distinct in nature and in origin.

It is noteworthy that the theory of dualism, as held by some recent philosophers who are thorough evolutionists, takes on a quasi-monistic type. Thus Lotze, though he finds himself constrained to adopt a dualistic conception in order to account for the unity of consciousness, makes the origin of the soul a gradual process. "So long as the soul was regarded as indivisible substance, it could only be supposed to enter the body at a single instant and in its entirety; whereas, if we renounce these ideas of an external conjunction, we need no longer wish to fix the moment at which the soul enters into a development which at first is supposed to produce only physical actions. There is nothing to prevent us from looking at the formation of the soul as an extended process in time, a process in which the Absolute gradually gives a further form to its creation."* Professor Stumpf, while keenly criticizing the difficulties of monism, verges yet more closely upon monism: "I would even find no serious difficulty in the assumption, that psychical life (soul) was produced by organic processes (organic material) in particular stages of their development, and is even now produced in the development of every individual."†

* *Metaphysic*, English translation, 2d edition, vol. ii, p. 184.
† *Eröffnungsrede*, Third International Congress for Psychology.

This is certainly very far from the old-fashioned dualism and creationism.*

Certainly there are not wanting strong indications that the psychical endowments of man are, like his physical characteristics, the result of a process of evolution. As we rise from the lowest unicellular organisms, we find complexity of structure and complexity of function advancing *pari passu.* Particularly we find those functions which seem to indicate intelligence advancing *pari passu* with the development of the nervous system. In the cerebral hemispheres of man we find a ganglionic apparatus far surpassing in delicacy and complexity that of any other animal, and in correlation therewith we find man manifesting an unequaled range and variety of psychical function.

It is not by any means easy to formulate the psychical differences between man and brute. The whole subject of comparative psychology is profoundly difficult, since, in the study of brute psychology, we are necessarily destitute of that light of consciousness which is the "master light of all our seeing" in human psychology. We cannot even demonstrate the falsity of the position which Descartes and some other philosophers have held, that brutes, even the highest, are absolutely destitute of consciousness; that their apparent manifestations of intelligence are only apparent; that the pathetic cry of a wounded dog differs from the cry of the toy dogs which children pinch, only in being produced by a mechanism more delicate and com-

* See also Ladd, *Philosophy of Mind*, p. 363.

plex, both mechanisms being alike unconscious. But, though that view is not demonstrably false, it has never commended itself to many thinkers as probable. The actions of the higher mammals are so much like our own that it seems immensely probable that those actions have their root in psychical states essentially similar to ours. And when we attempt, on the basis of inference drawn from outward actions, to discriminate the range of psychical faculty common to brute and man from that which is peculiar to man, it becomes obvious that clear delimitation is difficult or impossible. Again, the endowments characteristic of humanity manifest themselves not all at once, but gradually, in the life of the individual and in the life of the race. The new-born infant manifests none of the characteristic mental endowments of humanity. Months must pass in his development before he is capable of any action distinctively human. The phrase which we so constantly use in regard to the early history of our race, "the infancy of humanity," is far more than a figure of speech. It recognizes the truth, confirmed by all sources of evidence, in regard to the prehistoric condition of humanity, that the dawn of distinctively human endowments was gradual in the race as in the individual. The development of psychical faculties in the human individual, so far as they are common to man and brute, seems to follow the same order that is shown in the succession of animal forms from those low in the scale to the highest. In other words, in psychical endowment there seems to be the same paral-

lelism between ontogeny and phylogeny which exists in respect to physical characteristics, and which has been referred to* as affording strong evidence of the theory of evolution in general. It is difficult to see why that parallelism of ontogeny and phylogeny does not have the same significance in regard to psychical as in regard to physical characteristics.

If we were acquainted with no creatures between inorganic matter and man, there would be little room for doubt that the dualistic philosophy would best formulate the facts of our experience. But the series of gradations afforded by the lower orders of life introduces great perplexity in the application of that philosophy. How much of the group of characters which distinguish man from inorganic matter shall we attribute to the presence of a soul or spirit? and how many of the other creatures on earth, if any, shall we suppose to be endowed with such an immaterial entity?

Three possible alternatives present themselves:—

1. We may suppose that man alone has a soul, and we may consider as diagnostic of its presence the higher, supersensuous range of mental life which seems to be peculiar to man. Theologically, this view is convenient, as furnishing a plausible ground for the assertion of moral responsibility and immortality as belonging to man alone. But we are brought into perplexity on the psychological side, when we attempt to deal with the fact that the actions of the higher animals are so similar to our own as to render it probable

---

* Page 183.

that they have to some extent the same psychical faculties. If we assume that in man the higher psychical faculties belong to the spirit and the lower ones to the body, we contradict the testimony of consciousness to the unity of our psychical life. If we assume that sensation, association, instinct, and other psychical faculties which appear to be common to man and brute, are functions of spirit in man and of body in brute, we attribute phenomena that appear identical to different causes. On both these suppositions we admit that matter may be conscious, and so undermine the foundation of dualism. There remains the alternative of denying that brutes are conscious. But few have the hardihood to take that position.

2. We may suppose that all animals have souls, and we may consider consciousness as the characteristic of soul. This would seem very plausible if our knowledge of the animal kingdom were limited to those animals which considerably resemble ourselves. There does seem, indeed, a chasm of inconceivable breadth between the conscious and intelligent life of a man, or even of a dog, and the unconscious life of a tree. But, as our knowledge of the kingdoms of animate nature becomes more complete, we recognize that animal intelligence is a thing of infinite gradations. The lowest animals show no more sign of intelligence than the lowest plants. Indeed, there is absolutely no line of demarcation between the lowest animals and the lowest plants. There is no character which can be affirmed to be diagnostic of the two kingdoms, and it is only

arbitrarily and conventionally that some of the lowest organisms are parceled out between the botanists and the zoologists. From the simplicity and apparent unconsciousness of unicellular life to the complexity and intelligence of mammalian life, the progress is by an indefinite series of gradations. Nowhere can we draw a sharp line of demarcation, and say, on one side is unintelligent, on the other intelligent, life.

3. We may suppose that all living things, vegetable as well as animal, have souls; and we may consider life as characteristic of soul. A plausible argument, indeed, has been advanced by Professor Ward* for the belief that plants have some rudimentary form of consciousness. The forms of life from which both plants and animals originated, along divergent lines of evolution, were in all probability possessed (like most animals) of the function of locomotion, though capable (like most plants) of feeding on inorganic materials. If motion in the lower animals is to be considered a sign of consciousness, then the ancestors of plants must have been conscious. Hence it may be imagined that some vague trace of consciousness survives in their descendants. It is of course as impossible to demonstrate the absence of consciousness in a monad or an oak as to demonstrate its presence in a dog or an ape. But a belief in the consciousness of unicellular organisms certainly rests on pretty shadowy foundations. In the structure and functions of a unicellular organism, it is difficult to see any more reason for postulating the ex-

---

* *Naturalism and Agnosticism*, vol. i, p. 287.

istence of a distinct spiritual entity residing in the organism, than in the structure of a crystal or the action of a magnet. Moreover, it should be noticed that any argument for a faith in immortality which may be drawn from a dualistic philosophy is of very doubtful theological value, if, by parity of reasoning, it requires us to claim immortality for toads and toadstools, monads and microbes. An argument which proves too much proves nothing.

In the perplexity as to the question where, if anywhere, a line is to be drawn between soul-endowed man and soulless inorganic matter, one is naturally reminded of the notion of a plurality of souls—vegetative, sensitive, rational—held by the medieval schoolmen. A modification of that view has been in recent years somewhat discussed in theological circles. The antithesis between ψυχή and πνεῦμα and their respective derivatives in several passages of Paul's Epistles* has given some support to a supposed Biblical philosophy which asserts for man a "tripartite" constitution, as body, soul, and spirit. There is no reason to believe that Paul intended to teach any definite system of metaphysics; and, if he did have such an intention, it would be important only to those who hold that the inspiration of the apostles made them inerrant.

The alternatives for the philosophical thinker seem to be dualism and monism, but with a third alternative of suspended judgment—agnosticism. Certain it is that there are three seeming interruptions in the con-

* I Thess., v, 23; I Cor., ii, 14, 15; xv, 46.

tinuity of nature, as traced by our present knowledge—between non-living and living, between unconscious and conscious, between non-human and human. We have no experimental evidence of the conversion of non-living into living matter, or of the origin of living beings otherwise than by normal processes of reproduction. However closely correlated cerebral changes and states of consciousness may be, the two classes of phenomena are utterly disparate, and we can conceive of no bridge spanning the chasm between them. However impossible it may be to formulate the psychological differences between brute and man, there is a chasm of measureless breadth between the psychical life of the brute, and the language and literature, the science and philosophy, the history and politics, the morality and religion, of man. The case would be clearer for dualism if there were one chasm instead of three.

It seems unmistakable that the tendency of biological thought in general, and evolutionary thought in particular, at the present time, is towards monism. But that fact is very far from conclusively establishing the truth of a monistic philosophy. The doctrine of evolution in its modern form has been before the minds of men so short a time that its real significance has not been adequately comprehended, and its correlation with other elements of knowledge and thought has not been thoroughly worked out. The present tendency toward monism may be simply an example of the crude and premature philosophizing which results from the dominance in thought of a new idea as

yet imperfectly comprehended. Whether the movement of the world's thought towards monism is a current destined to go steadily onward, or a tide which will flow for a few hours and then ebb, time alone can show. But surely in the present state of human thought we cannot feel that faith in duty and in immortality rests upon a very secure foundation if it can rest only on a dualistic philosophy.

We must find the foundation of ethics and consequently of religion, not in ontology, but in psychology; not in the assumption of a spiritual entity absolutely distinct from the bodily organism, but in the inexpugnable belief of personal freedom and responsibility. The *ego* believes itself, and cannot help believing itself, to be free and responsible; and that necessary belief affords a foundation for ethics and religion, which is altogether independent of any metaphysical dogmas as to the essence or the essences of the *ego,* and equally independent of any biological hypotheses as to the process by which the *ego* came into existence.*

It is often taken for granted that, if conscience in man is a product of evolution, moral distinctions have no permanent basis, and therefore no validity. President Schurman of Cornell University, however, has shown with great acuteness and wisdom that the question of the objective basis and validity of ethical distinctions is entirely distinct from the question of the origin of man's capacity for the recognition of moral distinctions. The eye is undoubtedly a product of evo-

* For fuller discussion of the freedom of the will, see p. 290.

lution, and in all probability the evolution of that organ has been mainly due to the principle of natural selection. But natural selection has evolved the eye only because the eye is useful, and the eye is useful only because its possessors live in a luminous universe. In like manner, President Schurman argues, the human conscience is in all probability a product of evolution, and its evolution has probably been due in large degree to the principle of natural selection. But natural selection could evolve a conscience only because a conscience is useful, and conscience is useful only because its possessors live in a moral universe—a universe governed by "a power which makes for righteousness." The eye and the conscience alike are useful only because they bring their possessor into relation with objective truth.*

That natural selection has operated effectively to force mankind into the practice of some of the virtues is certain. Those traits of character which we are accustomed to call the manly virtues, as courage and fortitude, enterprise and activity, fidelity and loyalty, must obviously have been greatly dependent in their development upon the stern action of natural selection. In intertribal warfare, those tribes which possess these virtues in greater degree will be sure to gain the victory, and the tribes less advanced in these respects will disappear by extermination or by absorption into the races that have conquered them. But Drummond, in his "Ascent of Man," and particularly in the bril-

* *Ethical Import of Darwinism*, ch. iv.

liant chapters on "The Evolution of a Mother" and "The Evolution of a Father," has shown how natural selection has operated in the development of a very different class of traits of character, namely, the domestic virtues. A certain degree of domestic virtue—a certain approximation to right relations between husbands and wives and between parents and children—is necessary in order that children in large numbers may be reared to maturity. A tribe which is destitute of the domestic virtues, must be few in numbers, because the children born will not be sufficiently well cared for to be reared to maturity. In default of parental care, they will early perish by disease or by starvation. In the ages of intertribal warfare, other things being equal, the tribe in which domestic virtues exist in such degree as to secure the rearing of large numbers of children must overpower the tribe in which the children are left to starve.*

Nor is faith in immortality dependent upon a dualistic conception of human nature. It is a profoundly significant fact that Christianity, with Judaism and Mohammedanism, which are respectively incomplete and corrupted phases of Christianity, stands alone among the religions and the philosophies of the world in teaching an embodied immortality. It is not the immortality of a disembodied spirit that Paul preached on the Areopagus amid the scoffs of Athenian philosophers,

* See also Fiske, *Outlines of Cosmic Philosophy*, part ii, ch. xxii. To Fiske belongs the credit of the fruitful suggestion that the lengthening of the period of infancy necessitated the permanence of the family, and was therefore a factor of inestimable importance in the evolution of the social and moral life of humanity.

but *ἀνάστασις*—resurrection. If a monistic philosophy should become established, it would indeed banish all forms of the faith in immortality which find their rationale in the conception of spirit as an essence distinct and separable from the body. The swan-song of Socrates would be hushed; but the voice of One greater and wiser than Socrates might still be heard as clear and strong as nineteen centuries ago, "I am the resurrection and the life."

Recent philosophical thought attaches very little value, as proof of immortality, to the supposed indivisibility of the soul.* Lotze, though advocating the philosophy of dualism, finds in the dualistic conception no valid argument for immortality. "The question of the immortality of the soul does not belong to metaphysic. We have no other principle for deciding it beyond this general idealistic conviction; that every created thing will continue, if and so long as its continuance belongs to the meaning of the world; that everything will pass away which had its authorized place only in a transitory phase of the world's course."†

A definite formulation of the method of immortality

* "We are not, I imagine, concerned to resuscitate the rational psychology of the Leibniz-Wolffians which Kant demolished, in order to establish the immortality of the soul on grounds which equally prove the immortality of atoms." Ward, *Naturalism and Agnosticism*, vol. ii, p. 192.

"The soul, however, when closely scrutinized, guarantees no immortality of a sort we care for. The enjoyment of the atom-like simplicity of their substance *in sæcula sæculorum* would not to most people seem a consummation devoutly to be wished. The demand for immortality is nowadays essentially teleological. We believe ourselves immortal because we believe ourselves *fit* for immortality. A substance ought surely to perish, we think, if not worthy to survive; and an insubstantial stream to prolong itself, provided it be worthy, if the nature of things is organized in the rational way in which we trust it is." James, *Principles of Psychology*, vol. i, p. 348.

† *Metaphysic*, English translation, 2d edition, vol. ii, p. 182.

must obviously transcend the reach of our knowledge. The dualistic doctrine permits a statement of the conditions of immortality in which the words appear intelligible; but, while the survival of a disembodied spirit may be a phrase verbally intelligible, it surely transcends the power of beings whose only experience of mental action has been in relation with a physical organism to conceive the actual meaning of disembodied existence. In a remarkable book entitled, "The Unseen Universe," published anonymously a quarter of a century ago, but later acknowledged as the work of Peter G. Tait and Balfour Stewart, two of the leading English physicists of this generation, a suggestion is offered which shows at least that the idea of immortality on a monistic basis is not irrational. These writers set forth the idea that the universe of matter is more complex than at first sight it seems. In addition to that form of matter which is tangible, physical science has already compelled us to postulate the existence of another form of matter, the luminiferous ether, so refined and tenuous that it does not directly impress our senses. Only by the supposition of such a more tenuous form of matter interpenetrating ordinary forms of matter, can we formulate the vibrations of radiant energy which are the ground of the phenomena of light and heat. That complexity which we have been already compelled to attribute to matter involves, of course, the possibility of still further complexity. There may be phases of matter as much more tenuous than ether as that is more tenuous than oxy-

gen or carbon. From a physiological standpoint, the condition of the persistence of memory and self-consciousness must be found in the continuous record of all our states of consciousness, which is made by the molecular changes going on in the brain. Though it is impossible to say what those changes are, no physiologist doubts that some cerebral change is correlated with every state of consciousness, and that thus the minute structure of the brain at any moment is a record of all previous experiences in life. At death, that record apparently goes to destruction, for the brain shares in that chemical decomposition which is the fate of the rest of the body. But, as Tait and Stewart suggest in the book to which I have referred, that record may be made in duplicate. When the brain that we can see and analyze and dissect suffers decomposition, there may survive, in some more tenuous form of matter which has interpenetrated the matter of the brain and shared in its developmental changes, a duplicate of that record of past states of consciousness, which may serve as a medium for the persistence of memory and self-consciousness in a future life. Of course the suggestion of these eminent physicists is not to be accepted as a dogma. The authors themselves had doubtless no such thought in regard to it. It is only a tentative suggestion, indicating that personal immortality on a purely monistic basis is not an irrational belief. It is surely a contribution of some value to religious thought to show that we can conceive of a possible method of immortality on a monistic basis. A somewhat similar

conception of the method of the future life, though not formulated in so definite accord with the conceptions of modern physics, is found in the teaching of that brilliant but erratic genius, Swedenborg.

A theological doctrine which must certainly undergo some change under the influence of a belief in evolution is the doctrine of the Fall. It is obvious that the evolutionist cannot accept as historic the story of Eden, as given in the second and the third chapter of Genesis.

The doctrine of the Fall, as it appeared in some of the older forms of Christian theology, was a tremendously far-reaching doctrine. It was supposed that not only man himself experienced a great change, but that the whole universe suffered a tremendous catastrophe, at the time of Adam's sin. Snow-covered mountains and burning deserts, deleterious weeds, venomous reptiles, and ravenous beasts, were supposed to be the result of the curse pronounced upon the world on account of Adam's sin. It is needless to say that geological science peremptorily excludes any such notion. But, after the idea of a general transformation of the physical universe consequent upon Adam's sin had been abandoned, the idea was still maintained that a vast and terrible change passed upon man himself. It was supposed that the earliest human beings were beings of supernal intellectual and moral elevation. In the striking language of Doctor South, a leading theologian of two hundred years ago, "an Aristotle was only the rubbish of an Adam." The same belief of the superiority of Adam and Eve to all their posterity is

expressed with somewhat doubtful grammatical propriety by Milton, when he calls Eve "the fairest of her daughters," and Adam "the goodliest man of men since born." Whatever we may think of the poet's grammar, there is no doubt about his meaning.

It is needless to say that the modern anthropologist cannot accept any such conception of the primitive condition of humanity. Such a conception, indeed, finds very doubtful support in the ancient traditions preserved to us in the early chapters of Genesis, and certainly finds no support in the discoveries of prehistoric archæology. The evolutionary anthropologist must of course believe that the human race originated in infantile weakness of intellect, and in that characterless innocence which necessarily precedes the beginning of moral conduct.

Nevertheless, while the legend of the Fall passes away, the doctrine of the Fall remains. For, beneath the form of legend, allegory, or myth, lies veiled the profoundest truth of human history. The interpretation of the doctrine of the Fall demanded by evolutionary anthropology may be expressed in a single word:—the Fall was not actual, but potential. There was no precipitation of man from a condition of supernal intellectual and moral elevation into abysmal degradation; but there was, with the first act of sin, a potential fall, absolutely measureless, in the forfeiture of possibilities inconceivably glorious. Imagine a race of animate beings becoming possessed, no matter how, of free-will and conscience. What imagination

can picture the possibilities of development in such a race if every volition of every individual were right? Beyond all thought would be the glory of humanity, in individual and in social development, in the progress of a civilization unmarred by sin. It is sin and sin alone that has forfeited that possibility of boundless glory.

The form in which that truth is expressed in the Eden tradition is essentially Semitic. A general tendency is personified. The transmission of the effect of sin from generation to generation, partly, doubtless, in spite of Weismann, by physiological inheritance, but chiefly, doubtless, by the effect of conscious and unconscious education, is represented under the symbol of a fall in Adam. We fell in Adam only in the sense in which we have fallen in all our sinning ancestors, and in all those whose sins are embodied in the evil traditions and institutions that pervert human life to-day.

To this conception of the Fall the soteriology of the New Testament adjusts itself without difficulty. Christ came, not to make man what Adam was, but to make man what Adam might have become if he had not sinned; not to restore a Paradise once possessed, but to create a Paradise whose boundless possibilities of glory had been forfeited through sin.

PART II

STATUS OF CERTAIN DOCTRINES OF CHRISTIANITY IN AN AGE OF SCIENCE

PART II

Status of Certain Doctrines of Christianity in an Age of Science

In the former part of this work we have traced the history of those scientific discoveries which have been chiefly important in modifying religious beliefs. We have traced the development of those three general conceptions which essentially characterize the scientific view of nature; namely, the extension of the universe in space, the extension of the universe in time, and the unity of the universe. We have pointed out the changes in theological belief which seemed to be necessitated by each of these great series of scientific investigations. We must now consider the present status of some important theological doctrines, not as affected by any one scientific discovery, but as viewed through the general intellectual atmosphere of a scientific age.

The Personality of Man*

The belief in a personal God is often called the fundamental doctrine of theology. There is, however, one other belief still more fundamental—the belief in a personal man. A man who believes himself to be

* See Fisher, *The Grounds of Theistic and Christian Belief*, ch. i. The reader will readily recognize my indebtedness to Professor Fisher's admirable discussion.

simply a ripple on the sea of events, and human life in general to be merely an episode marking a particular stage in the refrigeration of a nebula, is not likely to believe in a personal God; but one who thoroughly believes in his own personality generally finds it easy to believe in the personality of God.

The essential attribute of personality is self-determination. In discussing the theological bearings of the doctrine of evolution, it has been pointed out already* that the belief in the freedom of the will is not dependent upon any dualistic theory as to the distinction in essence between spirit and matter, and is not contradicted by the doctrine of evolution. The importance of that belief, as the foundation of all ethics and religion, merits a somewhat more extended discussion.

Doctor Samuel Johnson is said to have disposed of the question of the freedom of the will with the remark, "I know I am free, and that is the end of it"—a concise and a pretty satisfactory statement of the essential reason for believing in freedom. It is often, indeed, erroneously said that we are conscious of freedom. That, of course, is impossible. A man is conscious of nothing but actual mental states. He cannot be conscious of a potentiality. In accordance with a volition, I rise from my seat and begin to walk. I believe that I could have chosen to remain seated, but I cannot be conscious of that possibility. I am conscious only of the actual volition.

* Page 277.

The belief in the freedom of the will is like the belief in the trustworthiness of memory, the belief in the existence of an external universe, and other inalienable beliefs which enter into all our thinking. All these beliefs are undemonstrable, and most of them can be denied without logical absurdity. If any one denies the existence of an external universe, I certainly cannot prove to him its existence. If any one denies that memory is trustworthy, I cannot prove that it is; in fact, I have plenty of evidence in my own experience that my memory is not always trustworthy. Nevertheless I must trust my memory because I have nothing else to trust. All practical life and all scientific reasoning depend upon beliefs that have, in the last analysis, no other evidence than that we are so constituted that we have them and cannot get rid of them. If the whole physical and moral universe is an immense lie, it is at least a lie which we cannot detect and for which we are not responsible. If we act at all, we must act on the general postulate of the truthfulness of the universe. It is sound philosophy to assume the truth of our inalienable beliefs.

Even those who in their philosophy profess to believe in fatalism or determinism, act in all the practical affairs of life upon the belief of freedom. Their moral judgments of the conduct of themselves and others, and their spontaneous sentiments of complacency or remorse, of gratitude or resentment, bear testimony to a belief in freedom deeper than any philosophy; "their conscience also bearing witness, and their thoughts the

meanwhile accusing or else excusing one another."* In the old classical story, when Zeno, the Stoic philosopher, proposed to flog a slave that had been guilty of stealing, the slave answered, in the terms of the philosophy which his master had taught him, that it was fated for him to steal. The philosopher ingeniously saved his consistency by answering that it was fated also that he should flog the slave; but his feeling of resentment was doubtless the same as if he had made no profession of philosophic fatalism.

It is interesting to see how the philosophers who deny the freedom of the will deal with the common moral experiences of mankind. Spinoza has at least the merit of consistency. Holding the distinction of right and wrong to be merely artificial and conventional, he declares, "Repentance is not a virtue, or does not arise from reason; but he who repents of any deed he has done is twice miserable or impotent." A philosophy which thus repudiates the deepest moral convictions of humanity needs no other refutation. It is curious to see how John Stuart Mill, who was a man of intensely vigorous moral nature, sought deliverance from the conflict between his philosophic creed and his moral convictions. He tells us, "The true doctrine of the causation of human actions maintains that not only our conduct, but our character, is in part amenable to our will; that we can, by employing the proper means, improve our character; and that, if our character is such that, while it remains what it is, it necessitates us

* Romans, ii, 15.

to do wrong, it will be just to apply motives which will necessitate us to strive for its improvement, and to emancipate ourselves from the other necessity." But the ingenious attempt at reconciliation between his philosophy and his moral sense is obviously a failure, for the volition to use means to change one's character must be just as truly necessitated as any other volition. If I am paralyzed in all my limbs, I can no more reach out my hand to grasp a friendly hand that would uplift me, than I can rise without help and walk.

A belief which seems to be inalienable and necessary must be assumed to be valid unless it can be proved to be false. There have been some attempts to show that the freedom of the will involves a contradiction of accepted philosophical principles or scientific inductions. It is claimed sometimes that the doctrine of freedom contradicts the principle of causality. If the will, it is said, is not necessitated in its action by pre-existent conditions, the act of volition is an event without any cause. The simple answer to this philosophical objection is in the assertion that the very essence of personality is the capacity to act as an independent cause. I am myself the cause of my volition, and no other cause is needed.

Again, it has been alleged that the doctrine of the freedom of the will is contrary to the scientific induction of the conservation of energy. We have seen*

* Page 135. It is well to remark that the doctrine of the conservation of energy, though resting on strong grounds of probability, is, like all such inductions, undemonstrated and undemonstrable. It may not be absolutely and universally true. See discussion of Law in Nature, p. 321.

that, in the endless succession of changes in nature, it must be assumed that there is neither gain nor loss of energy, but only perpetual transformation. One form of energy passes into another, but an exact quantitative equivalence is maintained. There is no reason to doubt that the principle of conservation of energy holds in the changes of the human body, as truly as in the changes in inanimate nature; in the processes that go on in the cerebrum, as truly as in those that go on in the muscles. If, then, a series of psychical states beginning with a sensation and culminating in an act of volition is followed by a muscular movement initiating a further series of transformations of energy, it is argued that the nexus between the successive mental states must be of the same nature with the nexus between other terms in the series of events. I believe the true answer to this line of argument is in the position that the successive states of consciousness are not related as successive transformations of energy. Whether we adopt a dualistic or a monistic theory as to the essence of the conscious *ego,* it is certainly true that states of consciousness are an order of phenomena entirely disparate from those which are recognized by the physicist.* They may, for aught we know, inhere in the same essence; but, if so, that essence is so complex as to be the substratum of two sets of phenomena so utterly disparate as to have no quantitative relation to each other. All physical changes are movements of matter, formulable in terms of mass and

---

* Page 264.

velocity. But to speak of the mass or velocity of a state of consciousness is to use words without meaning. Our states of consciousness are not terms intercalated in the series of cerebral changes. They are another series parallel with the series of cerebral changes. The nature of the nexus between the two series is something absolutely beyond our ken. The changes in the sensory organs which follow a stimulus from the outer world, the changes in the cerebrum which are initiated by the changes in the sensory organs, the muscular movements which follow—all these doubtless obey the law of conservation of energy. But the states of consciousness associated with the cerebral changes are phenomena of a different order. They neither add to nor subtract from the energy of the cerebral movements.

Some of the attempts that have been made to illustrate the relation between volition and physical phenomena are based on wrong principles, and are misleading. Attention has sometimes been called to the fact that a movement involving a very small amount of energy often gives direction to a series of movements involving an immense amount of energy. The relatively small rudder directs the course of the large ship, although the energy involved in the turning of the rudder is but a minute fraction of that which rotates the screw. The energy required to pull the trigger of a gun bears a relation even more infinitesimal to the energy which is liberated by the explosion of the powder. So it has been said that volition represents an infinitesimal amount of physical energy, but

yet determines the course of a series of events involving vastly greater amounts of energy. Such analogies are false, for the relation between the energy that moves the rudder and that which turns the screw is only the quantitative relation of less and greater. The energy that pulls the trigger is likewise quantitatively related to the vastly greater store of energy liberated by the explosion of the powder. But neither volition nor any other mental state has a quantitative relation to physical energy. The recognition of the absolute disparateness of the two classes of phenomena is essential to sound thinking in regard to them.

Experience compels us to believe that volition is a cause of bodily movements. No man of common sense can doubt the fact. It is indeed from the experience of volition that the idea of causality is derived. But there is no reason to believe that the mode of causation is a transformation of energy. Volition is not transformed into muscular motion, as heat is transformed into motion in the steam engine. Transformation of energy is not the only kind of causation that exists in nature. Our volition determines the order and direction of the series of transformations of energy, primarily within our own bodies, secondarily in the outer world, not by contributing energy to the series, but by some other mode of causation none the less real because utterly incomprehensible. It is, indeed, no more incomprehensible that a mental state should be the cause of a physical movement than that a physical movement should be the cause of a mental state. The very

simplest mental act, that of sensation, has obviously its cause in the changes in the sensory organs induced by an external stimulus. It is no more incomprehensible that mental states should be the cause of physical movements than that physical movements should be the cause of mental states. In each case the link of causation is real. In each alike it is incomprehensible, and in neither is it a transformation of energy into a quantitative equivalent.

Again, it is objected to the doctrine of freedom that it is contrary to human experience. Men's actions, it is said, are capable of being predicted, and therefore they cannot be free. This line of argument takes two forms. In the first place, it is urged that the conduct of masses of men can be predicted. We can tell at the beginning of a year, with very close approximation to the truth, how many people in the State of Connecticut will commit forgery or murder or any other specific form of crime, how many will die by suicide, how many couples will marry, how many couples will be divorced. Now it is said that, since the conduct of men is thus predictable, it must be governed by some fixed law, and therefore the actions of men cannot be free. It is perhaps enough to reply that the approximate conformity of any particular class of phenomena to a law of averages shows nothing whatever in regard to the nature of the cause. It only indicates that, whatever the nature of the cause may be, it operates, when viewed statistically on a large scale, with an approximation to uniformity. With the supposition that

the will is free, and that every individual is absolutely the cause of his own volition, there is nothing incompatible in the fact that the number of volitional events of any particular kind should conform to a law of averages, since the substantial unity of human nature may be expected to show itself in a certain uniformity of average conduct.

But, secondly, it is said, we can not only predict by statistical methods the conduct of masses of population, but can also in many cases, with very strong degree of probability, predict the action of individuals. Of two young men going into the army, we say that the temptations of camp life will make one a drunkard, while the other will be proof against them. Of two men called to the treasurership of institutions or corporations, we say that one will steal the money with which he is intrusted, while the honesty of the other would be safe if he had to handle all the wealth of all the Indies. In a considerable proportion of cases, predictions of this kind made by men of shrewdness and knowledge of human nature are fulfilled. How, it is asked, can men's actions thus be predicted, if every volition is free? I am inclined to think the most satisfactory answer to that question has been given by Archbishop Temple in his Bampton Lectures.* The power of free agency, he tells us, though always potential in men, is, as a matter of fact, rarely exercised. It is exercised only in those critical actions of life which are the determining points of character. Com-

* *The Relations between Religion and Science*, lect. iii.

paratively few times in the course of an individual life is the question definitely raised between the choice of right and wrong. In the vast majority of cases, though potentially free, we act mechanically, simply following out the general plan of life which we have adopted, simply obeying the motives to whose guidance we have already surrendered ourselves. A simple illustration, for which the Archbishop is not responsible, will possibly help the understanding of his thought. I start from my house with a resolution to walk to the post-office. The action begins with a conscious volition, but that volition is not repeated at every step of the journey. Most of the steps, indeed, are not even conscious. The automatic action of the spinal cord maintains the rhythmic movement of my limbs until I find myself at my destination. In a manner somewhat analogous, we may say, at some critical epoch in his life a man consecrates his life to truth and goodness. He thus enthrones in his life a supreme purpose. In the exercise of his divine gift of freedom, he chooses duty rather than selfishness for the law of his life. But he does not have to make that solemn resolution every time he goes to church on Sunday, or to his office on a week day, every time he pays a debt, or gives a contribution to a missionary society. The details of his life simply follow spontaneously, mechanically, from the purpose once established. The two cases are, of course, not identical. In the former case, the successive steps of the walk are unconscious, and physiologically the nervous action involved is that of the spinal

cord. In the latter, the details of duty by which the general plan of life is put into effect are conscious, and physiologically they involve the action of the cerebrum. But the two cases are analogous, in that in each case a higher faculty is exercised in the initiation of a course of conduct whose details are carried into effect by lower faculties. The reason, then, why the majority of individual actions are predictable is that in most of them there is no exercise of free agency. Precisely the thing which is not predictable by human intelligence is the conduct of the individual in those critical moments when character is made.

Archbishop Temple further points out the immense moral advantage of that constitution of human nature which thus allows our actions to be virtually necessitated by our character. Therefrom it comes, in the moral development of the individual, that we do not have to fight over again the whole battle of life in every alternative of good or evil conduct which presents itself to us. There is, rather, the magnificent possibility that, by right decision in repeated critical instances, we can establish a character which will naturally and spontaneously practice the good. To that goal all moral education of ourselves or of others is directed. The full attainment of that goal is the blessedness of heaven.

It is frankly admitted that freedom is incomprehensible; that it constitutes an exceptional phenomenon. We find nothing like it in the inanimate world, and probably nothing like it in the lower animate world.

But in ourselves an inalienable conviction declares the possession of that power. The utter incomprehensibility of that power is no reason why its existence should not be believed. The belief in our own freedom stands in the same rank with other necessary beliefs. It contradicts no necessary belief, no well-established induction.

The Personality of God

Belief in the personality of man makes it easy to believe in the personality of God. Probably everyone who does truly believe in his own personality, believes in a personal God or in personal gods. The consciousness of our own volition gives the first idea of causation, in the experience of every individual. Hence primitive man refers all causation in nature to the will of beings like himself. In its crudest and most primitive form, theistic belief assumes an infinite multitude of little gods. This is the doctrine of animism. Every separate object which comes into relation with us, or affects us for good or evil, is conceived to be possessed of a nature like our own, and to act in a manner analogous to our own volition.

But, as man's knowledge of the material universe advances, the multitude of little gods tends to give place to a smaller number of larger gods. As knowledge grows, men see that it is not necessary to assume the existence of a separate soul in every leaf or in every stone. The phenomena of nature come to be more or less classified; and, instead of postulating a

separate intelligence for each particular object, men postulate a special intelligence whose volition shall be the cause of each class of phenomena. So the universe may be divided locally into various realms; and men may think of one god of the heaven, and one of the earth, and one of the sea, and one, it may be, of that mysterious under-world of whose existence the earthquake and the volcano give vague but terribly impressive intimations. Or, instead of a local classification, there may be a functional classification, as in the trinity of Hinduism, in which one of the great gods is conceived as the creator, a second as the preserver, and the third as the destroyer of all things. So, with increasing knowledge and deepening thought, animism develops into a more or less philosophic system of polytheism.

It is needless to say that animism and polytheism belong to stages in human development which the civilized world has long since passed by. The supreme generalization towards which science has moved from its crudest beginnings, is that of the unity of the cosmos; and in a scientific age polytheism is impossible. The *causa causarum,* the ground of the universe, may be personal or impersonal, intelligent or unintelligent: it must be one. The unity of the cosmos proclaims indubitably the unity of that cause in which the cosmos has its being.

The ground of belief to-day in one personal God is, in the last analysis, the same that led our savage ancestors to believe in an infinite multitude of little gods.

That ground of belief in the personality of God or gods is, in its most general statement, a more or less complete analogy observed between the phenomena of nature and the activities of man. It was doubtless the experience of human volition that first suggested a belief in a personal god. The argument for the personality of God turns now chiefly on the manifestations in nature of something like the intellectual activities of man. The argument for the personality of God, from the supposed manifestations of intellectual activities in nature, will be recognized at once as the argument which has been commonly called the argument from design. The function and the importance of the argument from design are recognized by all thinkers. The principle of causality forbids us to believe in an uncaused beginning. It compels us, therefore, to believe in the existence of something eternal and self-existent wherein lies the ground of all other existence. If there ever was a fool who "said in his heart, 'There is no God,'" meaning thereby that there is no eternal and self-existent something, the ground of all other existence, it is safe to say that in the intellectual evolution of humanity that particular species of fool has become extinct. But the admission of an eternal and self-existent something leaves unanswered the question whether that something is unintelligent or intelligent, a blind force or a free and moral personality. The function, then, of the argument from design is to establish the probability that the eternal something is intelligent.

Every one is familiar with Paley's classical illustration of the watch, whose mutual adjustment of parts bears testimony to the purpose for which it was made and to the intelligence involved in the making; and every one has recognized the ingenuity with which it is argued that the conclusion is not invalidated, although we may never have seen a watch made and may have no idea how it was made, although the watch sometimes goes wrong or seldom goes exactly right, although there are some parts for which we can discover no use, and although it appears, on further examination, that the watch contains within itself a miniature watch factory, and is capable of producing a progeny of watches. As the argument was worked out by Paley, the stress was laid chiefly upon intricate and complex mutual adjustments. His illustrations from nature were taken chiefly from the complex structures of the animal body. Of all illustrations the one which seemed to put the argument with the greatest cogency was that of the eye, as found in man and others of the higher vertebrates. The functional perfection of the eye depends upon the precise adjustment of the curvatures and refractive indices of a number of refractive media, placed in front of the sensitive retina, and guarded by a variety of protective apparatus. It can hardly be questioned that the force of the argument as presented by Paley is seriously impaired, when we consider that the eye, like all other animal structures, has come to be what it is by a process of evolution carried on mainly under the guidance of the

principle of natural selection. If the eye has come to be what it is by the survival of the fittest—desirable variations having been selected out of an indefinite multitude of variations which have occurred, while undesirable variations have disappeared by the extinction of their possessors, the evolution of the organ having begun with a form so simple as to be merely a pigment fleck covering the termination of a nerve,—it is certain that an argument based on the exquisite mutual adaptation of the parts of the eye does not have the same degree of cogency which it was supposed to have when the eye in its most perfect form was looked upon as an independent and original production. A homely illustration may perhaps make the point a little clearer. If we should find a vessel packed nearly or quite solidly with a variety of objects, in such wise that the small objects filled the chinks between the large ones, and every salient angle of one object fitted exactly or approximately into a reentrant angle of another object or into a space between two or more adjacent objects, there might be fair ground for an inference that some one intended the vessel to be full. But, if we were following the plan of the Paleyan natural theology, we should select for special consideration some object of exceedingly complicated form, and infer from the fact that its salient angles exactly corresponded with the reentrant angles in the adjacent objects, and *vice versa*, that its complex form was specially designed for the particular space which it was to fill. It cannot be denied that the force

of such an argument would be seriously impaired, if it could be shown to be highly probable that the vessel had reached its present condition by a process of shaking, wherein the small objects had gradually rattled into the chinks between the large ones, and the hard objects had impressed their form upon the soft ones. This homely illustration sets forth not unfairly the manner in which the Paleyan argument is affected by the doctrine of evolution, and particularly by the Darwinian theory of natural selection.*

The question is thereby suggested whether the argument from design is invalidated or only modified in its form. I believe that the latter alternative is the truth. Stress must be laid, not upon minute and special adaptation of particular structures, but upon the general aspect of law and formulable order pervading all nature. This thought is most happily expressed in a phrase used by the great mathematician, Benjamin Peirce, "the amazing intellectuality inwrought into the unconscious material world."† The argument from design, in the light of recent scientific thought, may formulate itself somewhat in this wise:—A book which we can read must have been written by an intelligence kindred with our own; the universe is a book we can read; therefore the universe is the work of an intelligence kindred with our own. Nature has a meaning to us, and is formulable by us, because it is the expres-

* An elegant illustration bearing in the same direction may be found in Romanes, *Thoughts on Religion*, p. 58.

† See a number of very striking quotations from this writer, in Fisher, *Grounds of Theistic and Christian Belief*, revised edition, p. 34.

sion of a mind of which our own minds are miniature counterparts.*

It may be remarked incidentally that the Darwinian theory of natural selection furnishes a relief from one of the difficulties which troubled the natural theologians of former times. The apparent wastefulness of nature, in the production of countless myriads of living creatures destined to be destroyed in embryonic or infantile stages of existence, has always seemed something unaccountable, and something very difficult to reconcile with the conception of a wise and benevolent Creator. Natural selection shows the meaning and the purpose of this apparent waste. It shows that this over-production has been the very means by which the more advanced forms of life have been developed from the crude simplicity of earlier forms. I do not mean to say that natural selection furnishes a complete theodicy. The unanswerable question may still be asked, whether there might not have been some better way of reaching the development of the higher forms of life than through this process of wholesale slaughter; but it is at least something to have shown that the seeming waste is not a waste, but is an effectual means of achieving a lofty end.

But man projects into the outer world, to form his belief in God, not only his volition and his intellectual

* "Nature itself is teleological, and that in two respects: (1) it is conformable to human intelligence, and (2), in consequence, it is amenable to human ends. In the first point mentioned we find implied that essential oneness of thought and being, that recognition of the intelligible by intelligence, that greeting of spirit by spirit, for which idealists have always contended." Ward, *Naturalism and Agnosticism*, vol. ii, p. 254.

activities, but also his moral nature. The sense of moral law, which is an inalienable attribute of humanity, suggests the notion of a lawgiver and a governor. Moreover, every individual, when he comes to consciousness, finds himself a subject of government in the family and the state; and the outward experience of governmental relations in society concurs with the inward experience of an inalienable conviction of law, to suggest the idea of a superhuman lawgiver and governor. The suggestion of a superhuman governor, thus derived, finds reinforcement in the not infrequent conspicuous examples of natural retribution for good or evil conduct. Though it is very far from being the truth that nature works upon man in his objective experience a systematic and consistent retribution, the cases in which virtue leads to prosperity, and flagrant and abominable sin brings exemplary doom, are sufficiently frequent to give considerable encouragement to the notion of "a power which makes for righteousness" outside of and above man. Hence, in all except the very lowest phases of religious belief, the gods have been conceived as moral governors.

The character which man attributes to the gods depends of necessity largely upon his own character. The gods may be conceived as indifferent to sin, except when it takes the form of personal insult to themselves or of contumacious defiance of their authority; or they may be conceived as absolutely impartial and incorruptible judges of all moral conduct. There is thus a truth in the remark of Feuerbach, that "man made

God in his own image." The same thought is expressed in Robert Ingersoll's new version of a familiar quotation, "An honest God's the noblest work of man." The ethical standard and the religious creed continually act and react upon each other. The nobler the idea of morality to which man has attained, the nobler will be the character with which he will invest his God. The nobler man's thought of God becomes, the more elevated will be his own moral ideals. But in the highest forms of religion, as in the lowest, the conception of God is derived from the experience of man. Hence the highest forms of religion are as truly anthropomorphic as the lowest. The faith which breathes itself in the prayer of all prayers, "Our Father which art in heaven," is as truly anthropomorphic as that earlier faith which gave us the story of Moses in the cleft of the rock, beholding the "back parts" of Jehovah, whose face no man could see and live;* as truly anthropomorphic as the mythology that has told us of the quarrels and amours of Olympus; as truly anthropomorphic as the notions of the savage who beats his idol when his prayers are not answered. The difference between the lower and the higher forms of religious faith is not that the former alone are anthropomorphic, but that the gross anthropomorphism of the lower faiths is changed for a more refined anthropomorphism in the higher. There is an anthropomorphism which attributes to God human limitations and imperfections; there is an anthropomorphism which

* Exodus, xxxiii, 18-23.

attributes to God the perfect ideals which man struggles after and forever fails to reach. But religion, low or high, in its origin, its evidence, and its essential nature, is anthropomorphic.

But, while all religion is anthropomorphic, it is nevertheless true that anthropomorphism has ever been the weakness of religious faith. Man is ever subject to conflicting motives, hence his conduct is always in greater or less degree fickle and capricious. His actions can never be predicted with any near approach to certainty. But very early in the experience of the human race it came to be recognized that many classes of natural phenomena can be predicted with substantial certainty. "While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease." The contrast between the predictability of natural phenomena and the unpredictability of human actions revealed the weakness of anthropomorphic faith. It was, I believe, Adam Smith who first called attention to the remarkable fact that gravitation has never been deified. There have been gods of sunshine and of storm, gods of birth and of death, but never a god presiding over that mysterious power which brings all heavy bodies down to the earth. The obvious reason for this exception to the general deification of natural agencies and potencies is that the absolute uniformity of gravitation renders it impossible to attribute its action to the will of a fickle and capricious being like man himself or like the deities made in man's image. This striking exception to

the polytheistic explanation of nature is a premonition of the "conflict of science and religion" which has made so large a part of the history of theological opinion in the monotheistic stage of religion. For, as man's knowledge of nature increases, class after class of physical phenomena is transferred from the realm of the unpredictable and seemingly capricious to the realm of the predictable and the law-governed.

The fact that natural events can be predicted, instead of leading to doubt or denial of personality in the power that dominates nature, should have led men to a recognition of the difference between finite and infinite personality. The brute has a nature, but no character. He is governed irresistibly by the impulse of each moment, responding to every stimulus from the external world which may affect his nervous ganglia. It is man's prerogative to choose among the impulses of nature, and thus, by the exercise of free will, to build upon the foundation of nature the superstructure of character. With God, perfect from all eternity and changeless in his perfection, nature and character are one. With perfect wisdom and perfect goodness, there can be no conflict of motives, no change of conduct. With perfect knowledge of the conditions, every action of a perfect being could be infallibly predicted. Freedom of the will is the heavenward ladder by which we climb from the animal to the divine. If we could reach that goal, our actions would be predictable, like those of God. That higher anthropomorphism which attributes to God, not man's

limitations and imperfections, but man's unattained and unattainable ideals, would have found no incompatibility between the uniformities of nature and the personality of the Power which dominates nature. Thus the conflict of science and religion might have been averted.

But men were not ready for that higher anthropomorphism. They clung to the lower anthropomorphism which fancied God "altogether such an one as" themselves. They could recognize no personality free from fickleness and caprice. They could recognize personal volition only in phenomena unpredictable and apparently lawless. A man may make a clock, wind it up, and leave it to run, occasionally interfering with its movements by moving the hands backward or forward, or by shortening or lengthening the pendulum. Then there will be uniformity in the ordinary movements of the clock, personal will and caprice in the occasional interferences. By some such conception theistic philosophy sought to take account of the uniformity of nature and the apparent breaches of that uniformity. The universe was conceived as a gigantic mechanism, which God, the great artificer, constructed and set in motion at some time in the remote past, thereafter only interposing on occasions more or less rare to modify the rhythm of its movements. By this conception divine agency was removed from nature, except in the initial act of creation and in occasional interpositions. God was seen only in apparent gaps in the continuity of nature.

So there came a departure from the universal primitive faith in the immanence of God. Animism of course identifies every natural object with the indwelling personality. The stone is itself the god that strikes the savage when he stubs his toe. In a higher stage of religious development, the poets are the priests and prophets of polytheistic nature-worship. The Shining One (Dyaus, Ζεύς) is at once the bright sky and the deity that glorifies it. In the monotheism of Hebrew bards, God was always conceived as immanent in nature. He brings "forth Mazzaroth in his season," and guides "Arcturus with his sons." "With clouds he covereth the light." "He giveth rain upon the earth." "He giveth snow like wool." "The God of glory thundereth." "His lightnings enlightened the world."

But the faith in the divine immanence which had glorified nature for Greek and Jew alike was abandoned by popular theology. Nature became godless. The "carpenter God" was an absentee God.

With this notion that the ordinary course of nature is independent of divine activity, and that God is to be seen only in the seeming gaps in the continuity of nature, the "conflict of science and religion" becomes inevitable. For the whole tendency of science is to fill the supposed gaps in the continuity of nature, and thus, as it appears, exclude God from the universe altogether. One by one, science annexes to the realm of law the districts in which lawless personal will had been supposed to reign. It leaves no place for the Divine Artisan. Men who no longer saw God in the sunrise

and sunset, crouched in superstitious terror at the manifestation of divine anger in the eclipse, until science showed that the eclipse was only a less frequent manifestation of the same system of law which is shown in sunrise and sunset. Then the darkness of the eclipse became as godless as the darkness of night. Banished from astronomy, God seemed to find an asylum in the realm of meteorology, for the changes of weather seem at first sight sufficiently capricious for the most grossly anthropomorphic deity. But, when the coming storm can be predicted though not even "a little cloud like a man's hand" can be seen, a God of tempest becomes as superfluous as a God of sun or moon. The tendency of science to close up the seeming gaps in the continuity of nature has found its supreme manifestation in the development of the doctrine of evolution. The nebular theory showed that there was no breach of continuity in the origin of planets; the evolutionary geology showed that there was no breach of continuity in the development of the earth's physical features; and the evolutionary biology showed that there was no breach of continuity in the origin of new species, and suggested, on the ground of analogy, the probability that there was no breach of continuity in the origin of life itself. It was, indeed, this stopping of the gaps in which alone the popular theology found the manifestation of God, that caused the agony of terror with which the theory of organic evolution was regarded for two decades or more after the publication of "The Origin of Species."

But analogy goes still further in the direction of maintaining the continuity of nature. The nebular theory traces the origin of the solar system from a nebula—most probably a swarm of meteors. But can we imagine that the nebula was absolutely the beginning? Does not analogy point to the belief that the nebula itself was evolved from some earlier condition of the matter of the solar system? And, when the solar system shall have finished this cycle of its existence, and the dissipation of energy shall have brought the present life of the world to an end, can we expect an absolute end, or must we rather look for the beginning of a new chapter of evolution? Again, can we look upon the atoms which are the units of chemical change as being ultimate and inexplicable facts—changeless since the supposed beginning of the universe? Few philosophical chemists would be content to rest in that supposition. All analogy would lead us to believe that the present atomic constitution of matter is derived by some sort of evolution from some unknown earlier condition. Analogy is indeed a treacherous guide, and often leads us astray. But it is no less true that analogy is a guide that conducts us to the broadest and noblest outlooks that the human intellect can attain. We must follow her cautiously, indeed, but it is a foolish timidity that refuses to follow her at all. It cannot be too often repeated that no conclusion resting only on analogy can be dogmatically asserted. But a qualified and tentative acceptance of the teachings of analogy is rational and prudent.

Thus science, in its well-established conclusions, and yet more in its analogical suggestions, contradicts the notion of the "carpenter God." It has no place for a God who dwells only in the breaches of continuity in nature. But, as we have already seen, this phase of the conflict between science and religion might have been entirely avoided, if men had been able to rise above that lower anthropomorphism which attributes to God the limitation, the imperfection, the caprice of man. The uniformity of nature is no contradiction to personal will, but only to the personal will of a finite, imperfect, changeful being. The will of a God who "is not a man that he should lie, neither the son of man that he should repent"*—a God changeless because perfect from eternity,—is not incompatible with the uniformity of nature: nay, is itself the ground of the uniformity of nature. Science tends to leave no gaps in which the Divine Artisan can find an asylum. But science has no contradiction to the faith in a God omnipresent and immanent—a God who dwells in the continuity of nature, not in the supposed breaches of continuity.

We must pause, however, for a parenthetic notice of a remarkable argument by which two eminent scientific men have sought to re-establish the faith in a "carpenter God." Sir John F. W. Herschel asserted, and Professor Clerk Maxwell more recently endorsed the assertion, that atoms have the character of a "manufactured article," and must therefore be held not to

* Numbers, xxiii, 19.

be eternal, nor to have been evolved, but to have been made by a Divine Manufacturer at some definite time in the past.* This stamp of a "manufactured article," from which so tremendous a conclusion is drawn, is seen in the supposed absolute likeness of the atoms of any particular element. Whether the atoms of hydrogen are detected in the atmosphere of the sun, or are liberated by the decomposition of water on the earth, the position of the lines which they show in the spectroscope appears to be absolutely identical. But obviously the apparent identity of the spectral lines proves only that the atoms are so nearly alike that, with our present means of research, we can detect no differences between them. When we are speaking of things of which we know so little as we know of atoms, there is logically a boundless difference between saying that we know no difference between the atoms of hydrogen, and saying that we know there is no difference. The assertion of absolute likeness of atoms, upon which so far-reaching a conclusion is based, goes immeasurably far beyond the evidence. It is pretty certain that in many cases the molecules in an optically homogeneous crystal are not exactly alike, but only approximately alike. It is, on grounds of general analogy, probable that atoms of hydrogen are only approximately alike. It is not unlikely that more refined modes of research may sometime detect differences between them. The argument of Herschel and Maxwell has received, on account of the high and well-deserved reputation of its

---

* *Encyclopædia Britannica*, art. *Atom*.

authors, an amount of consideration which on its own merits it does not deserve. Surely it is far more philosophical to accept the conclusions to which we are pointed by all analogies of scientific thought, than to contradict those conclusions on evidence so weak.*

The obvious goal to which the analogies of scientific thought are leading us, is the belief that the series of evolutionary changes which we see stretching backward into the remote past and forward into the indefinite future, has neither beginning nor end; that the nebulæ from which systems have been evolved were themselves evolved; that existing forms of matter were evolved from other forms that we know not, and may pass into other forms of matter equally unknown; that creative Power and creative Intelligence have been eternally immanent in an eternal universe. I cannot help thinking that Christian theology will be the gainer by the acceptance of such a view. We shall be relieved from the incongruous notion of a benevolent Deity spending an eternity in solitude and idleness. The contemplation of his own attributes might seem a fitting employment for a Hindoo Brahm. It hardly fits the character of the Heavenly Father, of whom we are told that he "worketh hitherto."† Surely no suggestion that has been offered relieves of its enormous unreasonableness the conception of the eternal

* For an admirable criticism of the position of Herschel and Maxwell, see Ward, *Naturalism and Agnosticism*, vol. i, p. 99. The notion of the mutability and probable evolution of atoms finds confirmation in the recent researches on radium and other radio-active substances. See lectures by Sir William Crookes and Sir Oliver Lodge, respectively, entitled, *Modern Views on Matter*, the former published in *Science*, 1903, vol. xvii, p. 993, the latter issued in pamphlet form by the Clarendon Press.

† John, v, 17.

solitude of God. The notion of the mutual complacency of the persons of the Trinity, in which some theologians have sought relief, is not much more satisfactory than that of divine self-contemplation, to say nothing of the fact that it involves a conception of the Trinity which verges towards tritheism. And the notion that eternal ages were spent in excogitating the best possible plan for a created universe contradicts any intelligent conception of divine omniscience and perfection.*

But is not the conception of God as eternally immanent in an eternal universe pantheism? Yes, and no. Certainly it is a phase of pantheism. But the system of doctrine usually called pantheism denies personality, free will, morality, alike in man and in God. In the line of thought which we have followed, on the contrary, we have started with the personality of man, and at every stage have firmly held to the personality of God. Thus we find the ground of all existence in the will of a personal God. Matter affects our senses only as it is a vehicle of force. Nay, the question recurs again and again to students both of physics and of metaphysics whether matter is anything but force. The supreme truth of theistic philosophy to which such a query points, is that matter has no existence apart from the continuous energy of divine will, "upholding all things by the word of his power." The existence of the material universe is thus an eternal act of creation.

* *Science*, 1899, vol. x, p. 950. See also Bowne, *Philosophy of Theism*, p. 189.

In the concluding chapter of his "Mental Physiology," entitled "Mind and Will in Nature," William B. Carpenter has wisely remarked that the conception of theism lies between the limits of pantheism and anthropomorphism. The cosmic uniformities which are the theme of science suggest the idea of a power whose nature is eternal law immanent in the universe. But the experiences of human life suggest to us, as truly as to our savage ancestors, the idea of volition, intelligence, morality, in God. Each of the two conceptions represents a phase of the truth. The mysterious Power "dwelling in the light which no man can approach unto, whom no man hath seen nor can see," can be represented in human language only symbolically. Strictly speaking, the doctrine of the personality of God can be true only in a symbolic sense. We can mean nothing more than that human personality affords the fittest symbol to represent some phase of the incomprehensible nature of Deity. The language of pantheism and that of anthropomorphism are alike symbolic. Whether we call God the Soul of the universe or the Heavenly Father, we are talking only in symbols. Indeed, so completely are the resources of language limited by human experience, pantheism can hardly express itself without anthropomorphic symbols. The very phrase, "Soul of the universe," is anthropomorphic.

Anthropomorphic symbols, then, are necessary to religion. Rightly understood, they do not contradict the truest philosophy. The Christian doctrine of the

Incarnation is the very glorification of anthropomorphism. Of all the great reconciliations wrought out by the revelation of God in Christ, not the least is the reconciliation between the human intellect and the human heart,—between science and faith,—between the philosophy that demands a God absolute, passionless, and changeless, and the religious affection that demands a human sympathy and love to which it can respond. We may with the pantheist believe in a God eternally immanent in an eternal universe, and yet, with a faith as simple as if we had never heard of evolution or conservation of energy, as simple as if we were living still amid the sweet legends of the childhood of the race, when Jehovah walked "in the garden in the cool of the day,"* we may take into our lives the blessedness of divine companionship offered in the words of Jesus to his disciples, "He that hath seen me, hath seen the Father."†

> "O Love! O Life! our faith and sight
>   Thy presence maketh one.
> As through transfigured clouds of white
>   We trace the noonday sun,
> So, to our mortal eyes subdued,
>   Flesh-veiled, but not concealed,
> We know in thee the fatherhood
>   And heart of God revealed."

Law in Nature

We have thus come to recognize as a probability the existence of a personal God immanent in nature—

* Genesis, iii, 8.

† John, xiv, 9.

a God transcending all human thought, yet capable of being in some sense defined between the limits of anthropomorphism and pantheism. There are some special topics which demand our consideration, as phases of the general subject of the relation of God to the universe. These special topics are Providence, Prayer, Miracle. But, before we discuss these topics, it seems desirable to enter upon a digression for the purpose of reaching as clear a notion as possible of the exact meaning of law in nature, and of the degree of probability of those propositions which are commonly stated as laws of nature. This digression is necessary because of the prevalence of erroneous notions of natural law. Natural law has been the fetish of modern thought, worshiped with most superstitious devotion by those who have least understanding of its real significance. Many people imagine that the cause of a phenomenon is completely explained by reference to natural law—that natural law is itself efficient cause. Many people imagine, likewise, when they see a proposition labeled as a law of nature, that that proposition is invested with an infallible certainty. It is therefore worth while for us to consider the nature and method of scientific thought, so that we may learn the true significance of natural law.

Science has nothing to do with entities. The scientist whose life is devoted to the investigation of the properties of matter, cares not, in so far as he is purely a scientist, whether matter has any objective existence or not. For him matter is simply the "possibility of

sensation." Whether matter is anything more than that, and, if so, what, are questions in regard to which scientific men, in so far as they are only scientific men, are the most utterly indifferent of Gallios. Science, again, has nothing to do with efficient causes. What we call physical forces are simply symbols, like the x, y, and z of the mathematician, which help us to express the relations between phenomena. When we speak of the force of gravitation, we mean nothing more than that projectiles, planets, and other bodies do move as they would move if all bodies were acted upon by a tendency to approach each other, varying in intensity directly as the masses and inversely as the squares of the distances. As to the nature of that tendency, the law of gravitation gives us no account whatever. If, in our speculation, we go a step farther, and propose to resolve the force of gravitation into the impact of moving particles of ether, we still know not, and do not pretend to know, what sets the ether particles in motion. The secondary causes with which scientific men deal are simply uniformities of sequence. As science knows nothing of efficient causes, so it utterly ignores final causes. The universe may have been made by an intelligent Creator; and, if so, he undoubtedly had some purpose in making it. But whether there was such a Creator, whether he had a purpose, and, if so, what the purpose was, are all questions with which science has nothing whatever to do. Science, again, knows nothing of primal origin or ultimate destiny. All that concerns the scientist,

purely as a scientist, is that the system of uniform sequences which we call nature appears to extend backward for an indefinite distance into the past, and seems likely to extend forward for an indefinite distance into the future. Whether that indefinite duration is infinite, is a question which science does not pretend to decide.

The work of science is to accumulate an increasing store of observations of physical phenomena, and by comparison and induction to detect the laws of those phenomena—i. e., the relations of coexistence or of succession which exist between them. And such laws, in addition to the facts themselves, comprise the whole content of science. In the progress of man's knowledge of the external world, those phenomena first engage attention which can be observed without any special appliances, and those relations are first perceived which are most simple and obvious. Subsequently instruments of precision enable observations and measurements to be more accurately made. Objects too minute or too distant to be seen by the naked eye are magnified. Ingenious experimentation devises artificial conditions under which the relation or lack of relation between any two phenomena can be detected. Improved mathematical analysis enables the mind to become cognizant of relations which are too intricate to be otherwise perceived. The mind stored with multitudes of facts acquires an almost intuitive power to penetrate into the secrets of nature, and discern far-reaching relations between phenomena appar-

ently utterly unconnected. But, in the very highest stages of scientific investigation, the work is still absolutely nothing but the accumulation of knowledge of phenomena, and the detection of relations of coexistence and of sequence between phenomena.

When the savage has learned to predict from experience the continued succession of day and night, the phases of the moon, and the changes of seasons, he has already developed the conception of natural law—i. e., of a determinate order of sequence in phenomena. When it is perceived that these obvious and familiar phenomena, in connection with infrequent and startling phenomena, such as eclipses, and phenomena only observable by the aid of the telescope, such as the phases of Venus, can all be included and formulated under the conception of a number of spheroidal bodies moving in elliptical orbits in accordance with the principle of gravitation, a much more comprehensive appreciation of the scope of natural law has been attained. When it is perceived that the same system of mutual attractions between bodies which has been assumed in order to formulate the actual movements of the planets, may account for the evolution of the planets from a nebula, and that thus a vast number of apparently unconnected phenomena—such as the high temperature of the sun, the cold and dead volcanic surface of the moon, the bright-lined spectrum of certain nebulæ, the internal heat of the earth, the wrinkling of the earth's crust into mountain chains—may all be brought into harmonious relationship, the con-

ception of the scope of natural law has been still further widened. But, when the astronomer plans years beforehand an expedition to the coast of Africa, to be in readiness to observe a solar eclipse at a precise point of time, or when the physicist tells us how many million years ago the surface of the earth became sufficiently cool to be habitable, he has only traveled some steps farther along the same road on which his savage ancestor had already entered, when that ancestor, warned by the diminishing altitude of the sun, turned back from hunting the mammoth with his stone spears and arrows, to gain the shelter of his cave dwelling before nightfall.

It is conceivable that a mind possessed of no faculties differing in kind from ours, and operating by the same sort of methods as those which have achieved the actual results of scientific investigation, might attain to so complete a knowledge of the relations of phenomena, as, by knowing simply the relative positions of the atoms in the primal nebula, to be able to predict the whole history of the solar system,—the magnitudes, distances, and orbits of future planets; the physiographic features of every orb—continents, oceans, mountains, rivers; the direction of every wind, and the number of drops in every shower; the precise moment at which life would animate a globe once lifeless; the character, number, and relations of every specific form of life; the number of leaves on every tree, and the exact position of every leaf.* It is con-

* Actions of man and other free agents would not be thus predictable.

ceivable that the path to be traversed by every atom, and the changes in which it would take a share, might be expressed in a mathematical formula of immense complexity, as truly as the orbit of a planet may be formulated. But, in the utmost extension of science which we can imagine, its entire content is still phenomena and laws—laws expressive of the relations of coexistence and sequence of phenomena.

All this sort of work involves, of course, one postulate of tremendous significance: viz., that nature is a system—a cosmos, not a chaos; and that, therefore, relations of coexistence and sequence observed within the limits of our experience may be expected to hold good beyond those limits. This postulate is as undemonstrable as the belief in personal identity, trustworthiness of memory, or moral responsibility, or any other necessary belief. But, as in the case of other necessary beliefs, its undemonstrability is no reason why it should not be accepted as the basis of our thinking. It is well, however, to notice that the postulate is implied in the common expectation of sunrise and sunset as truly as in the most comprehensive generalizations of science.

The content of science is, then, phenomena and laws; and those laws are simply formulas expressing relations of coexistence or succession of phenomena. But a little further illustration of the conception of natural law may be instructive. A good illustration of the scientific idea of law is furnished by mathematical series. A mathematical series is a succession of terms,

each one of which is derived from one or more of the preceding, in accordance with some law. Knowing a sufficient number of terms, we can discover the law of the series; knowing the law of the series, we can compute any term. A still more instructive illustration may be found in the geometrical conception of curves. A curve is conceived as being generated by a point which moves always in accordance with some law. That law, mathematically formulated, constitutes the equation of the curve. If a number of points of the curve are given, we can infer the law of the curve; if we know the law, we can predict any number of points, tracing the curve, it may be, from minus infinity to plus infinity.

The scientific conception of nature is that every group of related phenomena forms such a series—such a curve. Knowing by observation a certain number of terms of the series, or points of the curve—that is, a certain number of phenomena,—we make a guess, or, in technical language, an hypothesis, as to the law. By means of that hypothetical law, we predict other terms of the series, or points of the curve—that is, other phenomena which hitherto have been unobserved, or whose relation to the subject in question has been unrecognized. So far as opportunity may offer, the predictions are compared with the results of observation. So long as prediction and observation agree exactly or approximately, it is assumed to be probable that our hypothesis is exactly or approximately true. If our hypothetical law departs widely from the truth,

the departure will be shown, sooner or later, by a wide discrepancy between prediction and observation.

What I have said thus in the abstract finds a typical concrete illustration in Kepler's classical discovery of the character of the planetary orbits. Every known and recorded position of a planet was a point in a curve; and the contemplation of those known points suggested to the fertile imagination of Kepler hypothesis after hypothesis in regard to the law of the curve. At last the hypothesis was reached that the planetary orbits were ellipses with the sun in the focus; and with that hypothesis all observations were found to coincide. The conclusion thus established has never been questioned.

These illustrations, I believe, correctly set forth the general character of scientific research. The collection of a greater or less number of observations; the invention of an hypothesis suggested by those observations; the prediction, on the basis of that hypothesis, of phenomena hitherto unobserved or unregarded; the comparison of prediction with observation, and the consequent verification or refutation of the hypothesis—these are the ordinary steps in any scientific investigation.

If we carry out our geometrical illustration somewhat further in detail, it will yield us some interesting suggestions in regard to the conditions governing the relative degree of probability of different scientific beliefs. Let us suppose, then, that we are endeavoring to trace the whole course of a curve of which certain

points are given. It is obvious, in the first place, that, the more numerous are the given points, the more likely shall we be to form a true hypothesis in regard to the law of the curve. Other things being equal, the probability of our scientific hypotheses will be in direct ratio to the extent of our knowledge of the phenomena concerned.

Again, if we have a certain number of points of the curve given, it is evident that there will be much less liability of considerable error in conjecturing those portions of the curve which are intermediate between some of the known points, than in conjecturing those portions of the curve which lie outside the limits of the known points. Accordingly, if our observations of a series of phenomena are distributed over a given range in respect to time, space, temperature, pressure, or any other variable condition, we shall be much more likely to make predictions exactly or approximately correct in regard to phenomena lying within the limits of the extreme observations already made, than in regard to those which lie beyond those limits. In other words, interpolation is a much safer process than that which has been called, in barbarous defiance of etymology, by the name of extrapolation. Yet it must always be remembered that there is an uncertainty in interpolation, even between points which are very close together. Unless the equation of a curve is exactly known, we can never be sure that the curvature is uniform between any two points, however near to each other those points may be. There may be, for aught

we know, a cusp or a point of inflection between those two points. The man who, knowing the specific gravity of water at 32° and at 46° Fahrenheit, should infer that the specific gravity of water at 39° would be the mean of those two, would be of course in error. A possibility of like error must exist in all cases of interpolation.

Again, if we endeavor to prolong our curve beyond the limits of the farthest point which is given, it is evident that the probability of considerable error must increase with each unit of distance through which we proceed. Our processes of extrapolation become more and more uncertain as we proceed farther and farther beyond those limits, in time, space, temperature, pressure, or other variable condition, within which our observations have been made. The position of the planets may be calculated with great accuracy some centuries in advance; but he would be a very rash man who would attempt to make an Ephemeris for the year of our Lord 1,000,000,000. A man who knew the behavior of water at temperatures varying from 50° to 150° Fahrenheit could, on the basis of his observations, draw very just conclusions in regard to the behavior of water at temperatures somewhat below 50° and somewhat above 150°; but, if he attempted to carry his processes of extrapolation beyond the limits of 32° on the one hand and 212° on the other, he would undoubtedly be completely in error in his results. We know by experiment how the fusion point is affected by moderate increase of pressure in the case of

rather fusible bodies, as sulphur and spermaceti; but how the fusion point of the materials in the interior of the globe may be affected by the enormous pressure of four thousand miles of rock, is a different question. Geology, reasoning backward from the present to the past, can reconstruct with considerable accuracy the geographical, climatic, and other conditions of Quaternary and Tertiary times; but its pictures grow more and more indistinct as the vision is prolonged farther backward into the past, and the condition of the earth in Archæan time is very largely unknown. The biologist succeeds very well in tracing some of the later steps of the evolution of organic forms; but the origin of the various sub-kingdoms whose representatives swarmed in the Cambrian seas is shrouded in mystery; and we have scarcely a conjecture to relieve our absolute ignorance in regard to the origin of the earliest forms of life. The degree of probability of our conclusions diminishes rapidly, as those conclusions transcend the limits of observation.

Again, a curve of one of the higher degrees often consists of two or more branches apparently entirely distinct from each other; and it may happen that one of these branches has in its general form a close resemblance to a complete curve of lower degree. Thus, the curve which is represented by the equation,—

$$ay = \pm\sqrt{x(x-b)(x-c)},$$

has, for certain values of the constants, an oval branch whose form is very similar to that of an ellipse, and

an infinite parabolic branch. If we had given a number of points of that oval branch, and no points of the other branch of the curve, our conjecture would naturally be that the curve was an ellipse; and, if the observed points did not exactly correspond with the equation of the ellipse, we should probably suppose that the slight discrepancy was due simply to errors of measure-

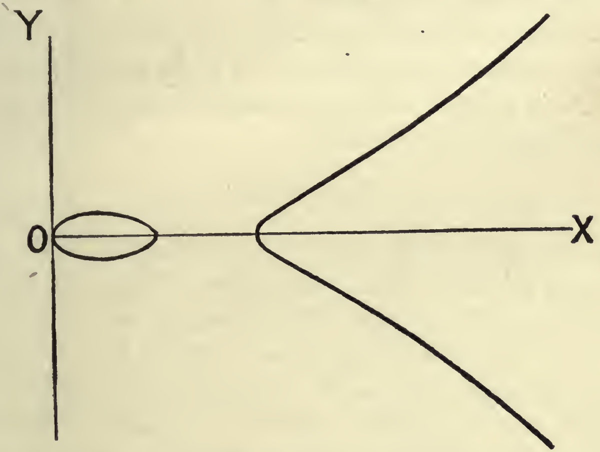

FIG. 14.—Curve represented by equation, $ay = \pm\sqrt{x(x-b)(x-c)}$.

ment. We should, of course, be in error. The curve is not of the second degree, but of the third degree. No part of it is an ellipse. The resemblance of a part of it to an ellipse is only approximate. I believe that we must recognize the possibility of an analogous error in our scientific investigations. A law which appears to be thoroughly verified by the coincidence between prediction and observation may yet be true

only approximately and within limits. It is possible, for instance, that the Newtonian law of gravitation may be only an approximation to the truth. It is possible that the true law may be a vastly more complex one, which would include in a single formula not only the relations of sensible masses of matter at sensible distances, but also the relations of molecules and atoms at infinitesimal distances.

Our geometrical illustration may afford us yet another instructive suggestion. If, in the equation which we have quoted, we make b equal to 0, the equation will reduce to the form,—

$$ay = \pm x\sqrt{x-c};$$

and we shall then find, corresponding to the oval branch of the former curve, only a single point, as shown at O, in Fig. 15. The curve will thus consist of an infinite parabolic branch and a single isolated point. In such a curve, there might be given a very large number of points distributed along the parabolic branch, and yet their contemplation might afford us no suggestion of the isolated point that lies outside of that branch. There must be always an analogous possibility, in regard to those natural laws which seem to be most thoroughly verified, that there may be outlying, isolated phenomena, apparently entirely unrelated to the law, which would yet be included in a true statement of the law. Such outlying phenomena, analogous to isolated points in complex curves, would afford us, from the physical

side, a conception of miracles. From this point of view, we recognize that a miracle need not be regarded as a suspension or violation of law. On the other hand, the physical significance of a miracle would be, that

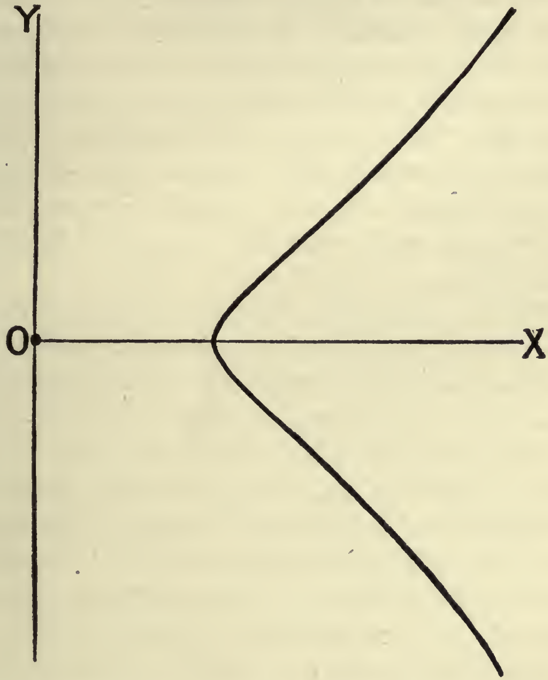

FIG. 15.—Curve represented by equation, $ay = \pm x\sqrt{x-c}$.

the true law of nature is more complex than our supposed law—that our supposed law is only true approximately within limits; and that the true law, in its full complexity, includes the apparently isolated phenom-

ena, as well as the phenomena which are apparently normal. It may be that the rising of Jesus from the dead was as truly natural as the failure of other men to rise. It is unnecessary to remark that the theological conception of miracle would require another element to be included in the definition; namely, coincidence in time and place between such an extraordinary event and some moral or religious revelation. The question of the probability or provability of miracle will be considered later.* All that concerns our present line of discussion is the recognition that a miracle must always and everywhere be among the physical possibilities.

This long digression has perhaps enabled us more clearly to recognize the significance of natural law. We have learned that a natural law is a statement of a relation of coexistence or succession in phenomena, reached by induction from a limited and partial experience, sometimes attaining a very high degree of probability, but never able to reach the standard of certainty. We have learned that law in nature has absolutely no shadow of causal significance. There are two and only two opinions possible in regard to the cause of those uniform relations of coexistence and succession which science brings to light. The cause is to be found either in blind, self-acting forces inherent in matter, or in the will of an immanent Intelligence. The former view is held by all atheists, most deists, and many Christians. The atheist of course holds

* Page 351.

that matter is eternal, and that its forces are not only self-acting but self-existent. Deists have generally believed that the material universe was created by a Deity who in the act of creation endowed matter with its wondrous potencies. Many Christians have held the same view, modified only by the doctrine of occasional divine interposition. While the ordinary affairs of the universe are carried on by the self-acting forces with which matter has been endowed, God is supposed occasionally to alter the action of the machinery by the interposition of his personal activity. These interpositions are called special providences or miracles, according to the degree in which the event is startling and unexpected. The form of conflict of science and religion to which this doctrine of divine interposition inevitably leads has been already sufficiently discussed. God is everywhere or nowhere in the universe. He does everything or nothing. All philosophic theists must hold that the cause of the uniformities of nature is to be found in the will of an immanent Intelligence, whose plans are changeless because his wisdom is perfect from all eternity. Not an atom of matter has ever changed its position but in obedience to his will.

Providence

The doctrine of Providence is an obvious corollary of the doctrine of immanent intelligence in the universe. For, if all events in nature obey the will of intelligent personality, then all events in nature are

purposeful. Nor are we altogether ignorant of the purposes which dominate the universe. Nature itself reveals in some degree the divine benevolence. In the relation of the universe to human conduct there is some evidence of "a power which makes for righteousness." But Christianity brings clearer revelation of the supreme moral purpose of the divine administration. The God revealed in Christ Jesus is a God whose supreme end is holiness. The kingdoms of nature are tributary to the kingdom of grace. Thus we recognize that providence is not an exceptional interference with the course of nature. The course of nature is itself providence. Natural law and providence are not, as men have fancied, conceptions contradictory and mutually exclusive. Law and providence are only two phases of the same truth, like the two sides of the fabled gold and silver shield. The very etymology of the word should have taught us that *pro-vidence* is not afterthought, but forethought—foreseeing, and consequent foreordaining: not the tinkering of a machine so clumsily constructed that its working fails to accomplish its designer's purpose—the shoving backward or forward of the hands of a clock which fails to keep good time; but the orderly working of infinite wisdom whose eternal plans need no modification because perfect always.

And, when we come thus to think of all nature as a system designed to carry out the purposes of God's providence, we need not trouble ourselves much about the foolish question, whether God's providence is spe-

cial or only general—whether it extends to all details of individual experience or only to the general course of things. The question could never have been raised but by men whose conception of God was controlled by that lower type of anthropomorphism which attributes to God human limitations and imperfections. Our finite intelligence cannot think of many things at a time. When we think of a general plan, we lose sight of details; when we concentrate our attention on details, we lose sight of generalizations. Attributing the same psychological limitations to the Deity, we have imagined that he could not consider our personal experiences while he was evolving into planets some far-off nebula; and that, if he condescended to sympathize with some little human sorrow, he would forget to keep Uranus and Neptune in their orbits. The thought only needs to be distinctly formulated for its absurdity and impiety to be manifest. If we believe in a God at all, we can believe in a God who is competent to manage the universe in gross and in detail. To the Infinite Intelligence, *all* and *each* are alike present. God does not forget details in generalizations, nor lose generalizations in details. As nothing is too great for his power, nothing is too small for his attention. He guides the flakes of star-dust slowly gathering into worlds; he marks no less the fall of the sparrow, and numbers the hairs of our heads. No meteor, no animalcule, no atom escapes the infinite watchfulness of omniscience, or is forgotten by the all-embracing wisdom of providence.

Nor shall we in our thought limit the idea of providence to events that seem to us desirable. Many good people attribute prosperity to providence, adversity to natural law. If they have recovered from sickness, the recovery was providential. If their friends have died, death came by natural law. So they attempt to draw a line between the things which God does himself, and the things that occur in obedience to the laws of nature; or, as sometimes expressed, the things that God purposes, and those that he only permits. God does not shirk the responsibility of the universe. There is no occasion for us to try to prove an *alibi* for the Omnipresent. A far nobler and truer faith was that of the Hebrew prophet who declared in the name of Jehovah, "I form the light, and create darkness; I make peace, and create evil; I the Lord do all these things."* Darkness and death are as truly providential as light and life.

There is indeed one tremendous exception to the scope of providence. If we believe in free will, we must recognize that for our own sins we are ourselves responsible. Providence enters not into the sacred sphere of human personality. But our responsibility and control are limited to the subjective sphere of our own volition. The objective results of our actions enter into the realm of providence, as truly as do the movements of inanimate nature. A reckless young clerk in India became desperate, and twice put a pistol to his head and pulled the trigger. Twice the pistol

---

* Isaiah, xlv, 7.

missed fire; and Clive lived to found the English empire in the East, and to annex those rich territories to the domain of civilization. The guilt of suicide belonged to the young man. It was God's providence that overruled the sinful purpose, and spared the life for great achievement. No crime can be consummated—no sinful purpose can attain objective fulfillment,—unless the result contributes to the advancement of the eternal plans of God. "Surely the wrath of man shall praise thee: the remainder of wrath shalt thou restrain."* We are bound then to recognize as providential those experiences that come to us as the result of the follies and sins of others or of ourselves.

Thus the philosophy of our age of science leads us back to the simple faith in God's presence and God's immediate activity in all life's experiences that is enshrined in the Hebrew traditions of the infancy of the race. The whole earth becomes an Eden in which God walks and talks with every soul that is pure enough to receive the manifestation of his presence.

> "We lack but open eye and ear,
> To find the Orient's marvels here—
> The still small voice in autumn's hush,
> Yon maple wood the burning bush."

PRAYER

The consideration of the doctrine of providence leads naturally to the consideration of prayer; for, in its broadest sense, prayer is simply the expression of our

* Psalm lxxvi, 10.

faith in providence. Prayer, then, will be gross or refined, rational or irrational, according to the character of our faith in providence. In the grosser anthropomorphic conceptions of God, he is supposed to be imperfect in knowledge, and therefore capable of change of purpose. He may be convinced by argument that the things he had intended to do are not the best, and may be led accordingly to change his plan; or he may be over-persuaded by persistent entreaty. With this low conception of the character of God was associated a correspondingly low idea of prayer. Prayer, in short, was simply teasing. Yet we may easily think too contemptuously of the gross anthropomorphism of early faith, and of the superstitious prayers in which that faith expressed itself. "It were better," said Lord Bacon, "to have no opinion of God at all than such an opinion as is unworthy of him."* A monstrous falsehood, for finite thought of the Infinite must be unworthy. Better—far better—the grossest anthropomorphism, than atheism. Better the most superstitious prayers of those who "think that they shall be heard for their much speaking," than irreligion. Crude and gross as were those early faiths and the prayers which they prompted, they kept alive in the human soul the great truth of a Power above man which can yet sympathize with man.

But, important and necessary as were these crude ideas of prayer in the history of religion, they could not be permanent. The advance of the human intellect

---

* *Essays, or Counsels Civil and Moral*, xvii.

in general, and especially the growth of scientific ideas of nature, brought their inevitable doom. We cannot believe to-day that, if God has purposed up to a certain moment to do a particular thing, he will change his mind and decide to do something else in obedience to the dictation of our prayers. Such a notion would imply either that God's wisdom was so imperfect that our prayers could convince him of the desirability of a change of plan, or that his purpose was so weak that he could yield to our simple importunity. The man who believes that God will change his plans in obedience to his prayer, and still dares to pray, must be possessed of a sublime hardihood. If I could fancy that God was willing to abdicate the throne of the universe in my behalf, I would not accept the tremendous responsibility.

But there is a truer conception of prayer correlated with that conception of providence which we have reached in our previous discussion. We have seen that providence is not afterthought but forethought—foreseeing, and consequent foreordaining. Prayer and its answer are provided for in the eternal foreknowledge of God. From all eternity God has foreseen the life of every human being; not merely the outward life as it manifests itself to men, but inward spiritual life as revealed to him alone. From all eternity God has heard all words of prayer which his church has offered and will offer to the end of time. He has heard the unuttered thoughts of prayer which were audible to his ear alone. From all eternity God

has known what souls would be lifted up to him in filial trust, and what souls, forsaking the Father in pride and unbelief, would doom themselves to spiritual orphanage. Knowing thus the spiritual condition of every individual at every moment, God has formed the constitution of the universe so as to bring to his children the blessings which he deemed fit to bestow upon them. In this view, the answer to prayer is not an exceptional thing; it is the very law of the universe. Answers to prayer come to us not contrary to law, but in harmony with law, and in the very course of the operation of law.

In the relation of prayer to the laws of the moral universe, we recognize the ground of the omnipotence of prayer in a certain sphere of our life. For law in the moral universe is as real as in the physical universe, and as real in the same sense. The order of coexistence and succession is as constant in the moral world as in the physical world. When we pray for forgiveness of sin, and for the grace which is needful for victory over temptation and for holy living, our prayer is itself, in the eternal system of moral law, the antecedent of which those blessings are the consequent. The state of mind which expresses itself in those prayers is the necessary condition for our reception of those gifts of divine grace. In such prayers as these, we are warranted in the faith that the specific thing asked for will be granted. To doubt that such prayers will be answered is to doubt the faithfulness of God. Such prayer, in the beautiful language of Doctor

Bartol, is "an address to the Throne, moved by the King himself." To such prayer may be applied without limitation the words of Jesus, "Ask, and it shall be given you; seek, and ye shall find." By the omnipotent might of such prayer the mountain weight of guilt is cast into the ocean depths of divine forgiveness.

Outside of this supreme sphere of prayer, all petitions must be offered in the spirit of submission. Expressly or by implication, the prayer, "Thy will be done," must be the accompaniment of every request for specific gifts. The only faith which can reasonably be exercised is a general faith in the providential wisdom and love of God. "He that cometh to God, must believe that he is, and that he is a rewarder of them that diligently seek him."*

An interesting question that demands attention is, how is the form of prayer affected by the increasing knowledge of the system of natural law? We have already seen that the propositions which we formulate under the name of laws of nature are of varying degrees of probability, and that none of them can attain to absolute certainty. Yet there are many classes of phenomena whose laws have been ascertained with so near an approach to certainty that we can predict without any consciousness of doubt that a certain event will or will not come to pass. Is it possible for us to pray for an event whose occurrence or non-occurrence we can thus confidently predict? I believe that the common sense of the Christian Church practically con-

* Hebrews, xi, 6.

fesses the impossibility of petitions for such events. I do not believe that any man in this age and nation—at least any man of sound mind and of education—can pray that the day may be twenty-five hours long, that a heavy body which is left unsupported may be poised in air above our heads, that an amputated limb may be replaced by a new growth, or that a dead man may be recovered to life. Yet these events are no more truly governed by law than are events for which most Christians are accustomed to pray. Probably most Christians pray at times for changes of weather, and all or nearly all Christians pray for the recovery of themselves or of their friends in sickness. Yet meteorological changes and disease and health are as truly law-governed as the phenomena connected with gravitation. The difference is simply that in one class of cases we do, and in the other class we do not, have such a knowledge of the law as enables us to predict the event. The things which we cannot predict we can pray for. The things which we can predict we cannot pray for.

Thus we are led to a conclusion which seems offensive to many good people: namely, that the advance of the knowledge of nature narrows the sphere of prayer. That the advance of knowledge in the past has narrowed the sphere of prayer, in the sense of specific petition, is simply a matter of history. There was a time when, in the gathering darkness of an eclipse, men could pray that the shadow might disappear, and the blessed sunlight be given to them

again. We cannot offer such prayers now, for we feel sure that the prayers of the whole church militant would not shorten the duration of an eclipse a thousandth part of a second. Our children's children will probably be as incapable of praying for sunshine and rain as we are of praying that an eclipse may be arrested.

Yet there is a broader, higher view of prayer, in which it is seen that the sphere of prayer can never be narrowed by our advance in knowledge. Prayer is not merely specific petition. Prayer, in its broader and higher sense, is the communion of the human soul with God. It is the response of filial love and trust to the truth of God's fatherly providence. In the Sermon on the Mount, Jesus warns us against a low, heathenish conception of prayer—the notion that prayer is essentially teasing, and that men are to "be heard for their much speaking." He warns us against the idea that we are giving information to God, or reminding him of things which he is in danger of forgetting:—"Your Father knoweth what things ye have need of before ye ask him." Thus he seeks to lead us away from the lower to the higher idea of prayer; from teasing to trusting; from petty, selfish petition to loving communion with him who is infinite in wisdom and love. Then he gives us a form of prayer. How strongly that prayer contrasts with those we often offer! How little of self, how little of specific petition, how little of telling God what we think we want, how much of loyal submission and filial

trust! "Hallowed be thy name. Thy kingdom come. Thy will be done in earth, as it is in heaven." And the prayer is half done before the thought of self has entered. Then the whole range of temporal interests is disposed of in the single petition, "Give us this day our daily bread"—a petition expressive rather of faith in God's providing, than of a disposition to direct that providing according to our own notions. According to the narrative in Matthew's Gospel, our Saviour prayed in Gethsemane, "If it be possible, let this cup pass from me: nevertheless, not as I will, but as thou wilt." And again he prayed, "O my Father! if this cup may not pass away from me, except I drink it, thy will be done." Was the latter prayer less truly a prayer than the former? Was it not the nobler prayer, revealing, as it did, that the weakness of the flesh was conquered, and the momentary vacillation of purpose was ended? "He spake a parable," we are told, "to this end, that men ought always to pray and not to faint."* This precept, "always to pray and not to faint," or that of Paul, to "pray without ceasing,"† certainly does not mean the perpetual dinning of specific petitions into the ear of God: it means, rather, a spirit of filial trust and abiding communion with God. Prayer is thus conceived as being not so much a specific act as an habitual state of mind—a continuous recognition of God in all the experiences and in all the activities of life. He who makes some near approach to this ideal of prayer,

* Luke, xviii, 1.

† I Thess., v, 17.

will have no occasion to lament the limitation of the sphere of prayer, in that he can no longer ask for some specific things for which he or his ancestors might once have prayed. For him the sphere of prayer will be coextensive with human life, and the sphere of answer to prayer will be coextensive with the physical and moral universe. He can sing most truly,

> "In every joy that crowns my days,
> In every pain I bear,
> My heart shall find delight in praise,
> Or seek relief in prayer."

And for him, all things will "work together for good."* He will "be in league with the stones of the field; and the beasts of the field shall be at peace with" him.† "The stars in their courses" will fight against his foes. Amid all the vicissitudes of temporal prosperity and adversity, his serene and triumphant faith may express itself in the words of the Psalmist:—"The Lord is my shepherd; I shall not want. He maketh me to lie down in green pastures: he leadeth me beside the still waters. He restoreth my soul."

In the future as in the past, advancing knowledge and deepening experience must change the form of prayer; but, in every stage of intellectual and moral development, that form of prayer is most fitting which is most natural and spontaneous. The value of prayer lies not in the consistency of its language with a high type of theistic philosophy, but in the

* Romans, viii, 28. † Job, v, 23.

genuineness of its expression of filial trust in a Father's love.

> "The child that cries for soaring bird,
>   For moon or radiant star,
> Is not rebuked with angry word,
>   Though vain its longings are.
> If God is God, and God is love,
>   And we his children are,
> He will not frown from heaven above,
>   Though e'en we ask a star."

Yes, let us ask for stars if we think we want them. We shall not get them, but we shall get what is better than stars. Poor babies as we are in our weakness and ignorance, we may still be the children of God, and may be blessed in his fatherly love. The childhood of the individual and of the race, the childhood of intellectual and of spiritual life, will "besiege the throne of grace" with specific petitions for all sorts of absurd and impossible things. But, as knowledge grows from more to more, and more of reverence in us dwells, our prayers will more and more conform to the precept of the Master, "After this manner, therefore, pray ye: 'Our Father which art in heaven, hallowed be thy name. Thy kingdom come. Thy will be done in earth, as it is in heaven.'" "After this manner"—not necessarily in these words (though the words may be fit to be the perpetual liturgy of the Church Universal), but rather in this spirit of trust and submission in the presence of infinite wisdom and perfect love. "Thy will be done," sounds now as a

faint, sweet accompaniment, almost drowned in the vociferousness of desire. Swelling into organ fullness,

> "Loud as many waters' noise,
> Sweet as harp's melodious voice,"

drowning into silence the tumult of selfish passion, it becomes the eternal music of heaven.

Miracle

The Christian religion claims to be authenticated by miracles. But there is one miracle which stands in a very different relation to Christian faith from any other miracle, and which may well claim special consideration.

Other miracles served to authenticate a revelation. The resurrection of Jesus was itself an integral part of that revelation. There might have been more or fewer of those other miracles, and our general conception of the character and work of Jesus would have been still the same. If he had fed the multitudes with a few loaves once instead of twice, if he had raised a dead person to life once or twice instead of thrice, if any one or if some considerable number of the miracles recorded in the gospels had been left unrecorded, or if the record of some of them should be discredited as unauthentic, it would make no essential difference in our conception of the character and work of Jesus, or in the general system of Christian doctrine. But, if the record of the resurrection were lost or discredited, our whole conception of Christ and of Chris-

tianity would be radically changed. Something, indeed, of the work of Jesus would be left if the world should lose its faith in his resurrection.

> "In the wreck of noble lives,
> Something immortal still survives."

Whatever changes there may be in men's opinions of Christ and Christianity, human life will always be better for the ethical teaching of the Sermon on the Mount; human character will always be nobler for the example of sublime self-sacrifice on Calvary. But the residue which would be left if the world should lose its faith in the resurrection would not be historic Christianity. It was "Jesus and the resurrection" that Paul preached at Athens. The resurrection was the corner-stone on which the faith of the primitive Church was built. Whatever might remain if the resurrection should cease to be believed, it would not be Christianity. It would not be the faith that has made martyrs and missionaries—the faith that has transformed the world's history.

The resurrection of Jesus may well claim special consideration, not only because it is the most important, but also because it is the best attested, of all miracles. Indeed, so greatly does the evidence of the resurrection exceed that of every other alleged miracle, that our chief reason for believing in any other miracle as historic, is that the strong evidence for the resurrection suffices to establish a probability that miracle is a part of the divine plan of revelation. In the thought

of to-day, it is doubtful whether any other miracle is so strongly attested that it would be credible if it stood alone. The question of the credibility of miracle resolves itself into the question of the credibility of the resurrection of Jesus.

The fact cannot be overlooked that the question of the credibility of miracle is profoundly affected by that change of intellectual atmosphere which has taken place since the first century, and which was considered in the introductory chapter of this work. Then prodigies were readily believed on the slightest occasion and with the most meager evidence. The growth of science; the discovery of a vast body of laws of nature—generalizations of experience—supported by a wealth of induction which raises probability almost to certainty; the strengthening conviction of the universal reign of law in nature;—disincline men to yield credence to an allegation so remote from ordinary experience as that of a resurrection from the dead. Apparently in utter unconsciousness of the difficulties which the spirit of this age finds in the way of belief in a miraculous event, many of the teachers of Christian evidences simply point to the presumably honest contemporary testimony to the fact of the resurrection, and confidently declare that no fact in ancient history is so well attested. It is doubtless true that the weight of testimony which can be marshaled in behalf of the resurrection is greater than that on the strength of which most facts of ancient history are believed; but the truth of that proposition is by no

means sufficient to establish the credibility of the resurrection. We can no more judge of the adequacy of testimony to establish belief in any particular allegation, without regard to the character of the allegation, than we can decide whether a bridge is sufficiently strong, without considering whether it is to bear foot passengers or railway trains.

It is indeed unnecessary to spend time in proving that a miracle is possible. From the discussion which has been already given of the meaning of natural law, it appears that every so-called law of nature is a generalization based upon limited experience and incomplete knowledge; that the probability of such generalizations varies greatly in degree, but can never attain the standard of certainty; that those laws which seem most strongly supported may prove to be true only approximately or within limits; that there must ever remain a possibility of the discovery of an isolated fact contradicting the supposed law of nature, and showing that the true law is more complex than had been supposed. That the sun will rise to-morrow at the time predicted by astronomers, is extremely probable, but not certain. It may fail to rise. So long as human knowledge falls short of omniscience, we cannot be warranted in pronouncing impossible *a priori* any allegation which involves no self-contradiction. As Hume has well said,* "Whatever is intelligible and can be distinctly conceived, implies no contradiction, and can

* *An Enquiry concerning Human Understanding*, section 4; *Sceptical Doubts concerning the Operations of the Understanding. Essays*, Green and Grose's edition, vol. ii, p. 31.

never be proved false by any demonstrative argument, or abstract reasoning *a priori*." At other times, unfortunately, Hume used language inconsistent with this clear and sound statement.

But the possibility of miracle is one thing; the probability of miracle is a very different thing. While no one of those generalizations of our experience which we call provisionally natural laws can reach the standard of certainty, there are many of them which attain an extremely high degree of probability. Some of these generalizations rest on a collection of observations so immense and so thoroughly analyzed that the occurrence of a new fact which will contradict the generalization, though not absolutely impossible, is enormously improbable. Here we reach the ground of Hume's famous argument against the credibility of miracles. Hume's position is substantially that a miracle is *a priori* so enormously improbable that the falsity of any supposable amount of human testimony is more probable than the truth of the alleged miracle. The sophistical form in which Hume stated his argument has been justly criticized, and criticized by the agnostic Huxley,* as well as by Christian writers; but the force of the argument depends, not on the sophistical form, but on the truth which it contains. That truth is, that the amount and quality of testimony necessary to establish belief in any allegation vary with the *a priori* probability or improbability of the allegation, and that accordingly there may be allegations so

* *David Hume*, part ii, ch. vii.

enormously improbable that no supposable array of testimony would render them credible.

Of this principle, Huxley has given a striking illustration.* "If a man tells me he saw a piebald horse in Piccadilly, I believe him without hesitation. The thing itself is likely enough, and there is no imaginable motive for his deceiving me. But if the same person tells me he observed a zebra there, I might hesitate a little about accepting his testimony, unless I were well satisfied, not only as to his previous acquaintance with zebras, but as to his powers and opportunities of observation in the present case. If, however, my informant assured me that he beheld a centaur trotting down that famous thoroughfare, I should emphatically decline to credit his statement; and this even if he were the most saintly of men and ready to suffer martyrdom in support of his belief." Huxley goes on to say expressly, "This hesitation about admitting the existence of such an animal as a centaur" "need not imply, and it does not, so far as I am concerned, any *a priori* hypothesis that a centaur is an impossible animal; or that his existence, if he did exist, would violate the laws of nature. Indubitably, the organization of a centaur presents a variety of practical difficulties to an anatomist and physiologist; and a good many of those generalizations of our present experience which we are pleased to call laws of nature, would be upset by the appearance of such an animal, so that we should have to frame new laws to cover

* *David Hume*, p. 132.

our extended experience. Every wise man will admit that the possibilities of nature are infinite, and include centaurs."

Suppose all Roman historians for a century after the death of Nero agreed in the assertion that Nero rose from the dead. Would such agreement establish in our minds a belief in the truth of the allegation? I answer, without hesitation, "No." I believe that the majority of well-educated people would not even be brought to the point of seriously questioning whether the allegation might not be true. The supposition of error in all the historians of the period, arising from some mistake or fraud on the part of those who first gave currency to the story, would seem immensely more probable than the supposition of the truth of the allegation.

Why should we believe in the resurrection of Jesus on the evidence of testimony, when we can hardly conceive of any array of testimony which would convince us of the resurrection of Nero? The answer to this question may be given in two different forms.

I. In so far as the character of Jesus is unique and apparently superhuman, the *a priori* probability against the resurrection is diminished. If it is conceded that in various respects Jesus differs from all other men, it is thereby rendered more or less probable that he may differ from all other men in other respects. It is certainly true that the character of Jesus is unique. He seems to stand apart from mere men, like some mysterious visitor from a higher sphere. "Never man

spake like this man." He bids the world, "Take my yoke upon you, and learn of me; for I am meek and lowly in heart: and ye shall find rest unto your souls." What other lips could thus have put into a single sentence the profession of humility and the claim to supremacy over mankind without producing an impression of grotesque incongruity? On the lips of Jesus the two utterances blend in sweet and solemn harmony. Behold him in the days of the passion week and in the threefold trial on the morning of the crucifixion. How, with each accession of humiliation, he reveals more fully a serene and superhuman majesty! The lower he stoops, the higher he rises.

With whom among the sons of men shall we compare him? Shall it be with the saints of the Christian Church? The holiest of them loves best to confess that he only reflects some portion of the glory of Jesus, as the planets reflect the splendor of the sun. Shall we compare him with other founders of religions? Read the story of Buddha, as told so lovingly—too lovingly, perhaps, for strict and critical fidelity to truth—in Sir Edwin Arnold's "Light of Asia." Read the beautiful story with loving sympathy, and thank God that "he left not himself without witness" among the teeming millions of the Orient, but raised up for them a teacher of righteousness. "But the glory of the celestial is one, and the glory of the terrestrial is another." "The Light of Asia" pales before "the Light of the World." Try to patch into one of the Gospels the story of Buddha stealing out from his

sumptuous palace, past the lovely sleeping forms of his troop of nautch girls, when the wail of human sorrow calls him forth to his great mission—try to patch into one of the Gospels that story, as told so sweetly in Arnold's poem, or, still worse, as told more repulsively in the Indian original,*—and how wildly incongruous it would be! Among earth's saints and sages there is no peer for the Man of Nazareth. It is not incredible that he who was superhuman in life should have been superhuman in death.

II. For an atheist, or for an agnostic whose type of agnosticism is practical atheism, assuming that there is no moral purpose in the government of the world, there can be no meaning in a miracle, and such an extraordinary event is as improbable at one time as at another. That indeed is exactly the assumption of Huxley in his illustration of the centaur already quoted.† If there was a centaur in the streets of London, he was there for no moral purpose. He was an isolated and meaningless wonder. But to him who believes, or even hopes, that the world is ruled by a God of moral attributes, it must appear more or less probable that such a God may choose to reveal himself to his children, and may make the system of nature itself emphasize and attest that revelation. In proportion to the importance of the revelation which is to be made is the probability of some miraculous sign

---

* *Life of Buddha*, by Asvaghosha Bodhisattva, translated by Beal (Müller, *Sacred Books of the East*, vol. xix), p. 54.

† Fisher, *The Grounds of Theistic and Christian Belief*, revised edition, p. 171.

for its attestation. If the Power that rules the world is "a power which makes for righteousness," it cannot seem incredible or extremely improbable that the world's clock should have been so adjusted as to strike at an hour pregnant with moral destiny. When we consider that, but for the faith in the resurrection, Christianity would have been buried forever in the rock-hewn tomb in which the Master lay, and when we try to measure what Christianity, with its revelation of divine fatherhood, and human brotherhood, and redemption from sin, and life immortal, has been to mankind in these centuries of Christendom and Christian civilization, and what it promises to be in the glory of a millennial future, we cannot deem it "a thing incredible" that, in that transcendent crisis of man's moral history, "God should raise the dead." The thought of this paragraph may be summed up in a striking sentence from Romanes' "Thoughts on Religion":—"The antecedent improbability against a miracle being wrought by a man without a moral object is apt to be confused with that of its being done by God with an adequate moral object. The former is immeasurably great; the latter is only equal to that of the theory of theism, i. e., *nil.*"*

By such considerations as these the *a priori* improbability of a resurrection is so far neutralized that we are in a posture of mind to consider the testimony which can be cited in favor of the resurrection of Jesus. The resurrection of Jesus is not, as the resurrection of

* *Op. cit.*, p. 191.

Nero would be, an event so enormously improbable that scarcely any supposable testimony would suffice to render it credible.

The historic record of the resurrection is contained in six of the books of the New Testament—the four Gospels, the Acts of the Apostles, and the First Epistle to the Corinthians. The last of these has a peculiar importance, as being both the earliest in date and the most unquestionable in authenticity. Skepticism itself does not doubt that the First Epistle to the Corinthians was written by the apostle Paul, and at a date not more than about a quarter of a century after the death of Christ—at a time, therefore, when the greater part of the more than five hundred brethren who claimed to have beheld the risen Lord were still living. The summary of the appearances of the risen Christ to the apostles, as contained in that epistle, is therefore conclusive evidence that the faith in the resurrection was the faith of the first generation of Christians. It was not a myth that grew up slowly, when the original witnesses of the events of the life of Jesus had passed away, and the simple tradition which they left had come to be embellished by the imaginative additions of later generations. It was the faith of the disciples who were contemporary with Jesus. It must be freely conceded that there is not the same degree of certainty in regard to the date and authorship of the Gospels and the Acts as in regard to those of the First Epistle to the Corinthians. Yet I believe it probable that the three Synoptical Gospels existed in substantially their

present shape before the year 70 of the Christian era, and that the Fourth Gospel is the authentic work of John, written in his old age, toward the close of the first century. It is worth noting that even those critics who reject the traditional views in regard to the date and authorship of the Gospels, for the most part hold no longer to the extremely late dates assumed by many critics a few decades ago. It would be somewhat generally conceded at the present time that all four of the Gospels are virtually, if not exactly, contemporary records of the life and teaching of Jesus.

We have, then, probably six contemporary documents, written by five different writers, all belonging to the circle of the apostles and their immediate associates. The evidence of these records is in no wise weakened by the discrepancies between them. They are just such discrepancies as always exist between a number of honest but incomplete narratives of a series of transactions. To cavil at them is as malicious as it is foolish to attempt to harmonize them. The substantially historic character of the narratives and their trustworthiness as regards the main facts may be reasonably maintained, even if it be conceded that there is ground for the suspicion that some details of the story (as, for instance, the angelic apparitions)* may

* Furness has suggested, not without plausibility, that the "young man sitting on the right side, clothed in a long white garment" (Mark, xvi, 5), may have been no other than Jesus himself, indistinctly seen in the dimly lighted sepulcher, by the women, who as yet had no thought of the possibility of a resurrection. *The Power of Spirit Manifest in Jesus of Nazareth*, p. 68. It is a noteworthy fact, whatever its significance may be, that Peter and John saw no angels at the sepulcher.

be unhistoric—the result either of some mistake or confusion on the part of the original witnesses or of some early corruption of the tradition.

It is unnecessary to comment on the air of perfect simplicity and guilelessness pervading the gospels. A candid reader is continually impressed with the conviction that the writers of those books fully believed what they wrote. The Fourth Gospel is probably the only record by an eye-witness of the events connected with the resurrection, since the First Gospel, in its present form, is pretty certainly not the work of an apostle, though it very probably contains much material of which Matthew was actually the writer. In John's narrative we meet in richest abundance those little particulars which impress themselves upon the memory of an eye-witness, but which tend to lose their distinctness as a story is repeated by other persons. In the narrative of the visit of Peter and John to the tomb, we have such particulars as John's outrunning Peter, looking first into the open sepulcher, and seeing the linen clothes; his timid or reverent hesitation to enter; Peter's impetuous rush into the sepulcher, followed by John; the napkin that had covered the head of Jesus, "not lying with the linen clothes, but wrapped together in a place by itself." There is an air of photographic fidelity rather than of artistic selection of details. The very form of the narrative makes an almost irresistible impression that John is describing that which he has actually seen and experienced. The art of a Defoe would

scarcely suffice so perfectly to "forge the handwriting of nature."

The obvious honesty of all the narratives, and the circumstantial detail which marks John's Gospel as the work of an eye-witness, scarcely leave room for doubt that the sepulcher of Jesus was found untenanted on the morning of the first day of the week. In some way the body of Jesus had been removed. That fact, of itself, is of no miraculous character; and there is no reason, therefore, why, so far as that fact goes, the Gospel narratives should not be recognized as having the same degree of trustworthiness which belongs to other apparently honest narratives of unexpected, but not miraculous, events. The absence of a human body from the place in which it had been laid was a phenomenon which the disciples were certainly competent to observe. Assuming it to be substantially certain that the sepulcher was found empty on the Easter morning, we may remark that the faith in the resurrection derives some incidental confirmation from the impossibility of constructing any plausible hypothesis of the abduction of the body. It is difficult to imagine any motive which could have induced either friends or enemies of Jesus to attempt the removal and concealment of the body, even had there been no serious difficulties in the way of the accomplishment of such a design. This consideration derives some additional importance from the fact that, within a few weeks after the alleged event, the resurrection of Jesus was publicly proclaimed, and believed by multitudes, in Je-

rusalem—the very place where, if anywhere, evidence of the fact might have been forthcoming, if the body had been stolen from the grave.

I have referred to the unquestionably early date of the First Epistle to the Corinthians as being important in proving that the faith in the resurrection was not slowly developed after the contemporaries of Jesus had passed away. That date is, however, by no means the earliest period to which we can trace back the belief in the resurrection. There are indications that, by an apparently spontaneous and instinctive movement, the celebration of the first day of the week, or the Lord's Day, as a distinctively Christian festival, was established at a very early period in the apostolic age. The common notion that the Lord's Day was a modification of the Jewish Sabbath, or that the date of the Sabbath was changed, is entirely mistaken. The very phrase now so frequent, "Christian Sabbath," is not known to have been used by any writer before the twelfth century.* In the early church the two institutions were never confounded. Jewish Christians for a time observed both days. The tendency of some Gentile Christians to observe the Sabbath was explicitly rebuked by Saint Paul,† as a symptom of a lapse into Judaism. The Lord's Day was absolutely a new institution. It was a joyous commemoration of that day which the Christian consciousness recognized as the birthday of the church. The institution of the Lord's

* Hessey, *Sunday* (*Bampton Lectures*, 1860), p. 90.
† Gal., iv, 10; Col., ii, 16.

Day is, therefore, a most eloquent witness to the faith of the first generation of Christians in the resurrection.

But we need not depend on any document or institution to show that the belief in the resurrection goes back to the beginning of the history of the church. The very existence of the church is an unimpeachable testimony to the same effect. But for the faith in the resurrection, the church would have died with its Master and been buried in his tomb. "We trusted," said the disciples on the way to Emmaus, "that it had been he which should have redeemed Israel." But that trust was in the past tense. The death and burial of Jesus utterly destroyed the crude and unintelligent faith in the Messiahship of Jesus which the disciples had cherished, and they had nothing to take its place. They were utterly disheartened; and, in the loss of their Master, the bond was broken which bound them to each other. What was it that transformed these heartbroken, aimless men, with no common interest but the memory of a dead hope, into a firmly united, courageous band, ready to attempt at once the conquest of the world? It was the faith in the resurrection that wrought that transformation. The church itself is the monument of the event which produced that faith, and thereby gave the initiative to the course of Christian history.

But what was that event? If Jesus did actually rise from the dead, and appear unto Cephas and the twelve and the five hundred brethren, then all else is clear. The one great mystery of the resurrection explains

other mysteries. We have a sufficient cause for the transformation of character in the disciples and for all the subsequent course of history. But, if he did not rise from the dead, what was the event which happened on that Easter Day, and which created the faith in the resurrection?*

The answer which, probably, is at present most commonly given to this question, by those who deny the reality of the resurrection, is that the origin of the faith was in a vision or hallucination, which was experienced at first by a few of the more imaginative of the disciples, by whom, gradually, a sympathetic delusion was induced in others. As this theory has been developed by Renan, the credit of originating the notion of the resurrection is given to Mary Magdalene.† The mental malady of which she had been healed had left her imagination in a peculiarly excitable condition. The faith which has regenerated humanity, accordingly, had its origin as a pathological symptom in the brain of a half-crazy woman. Instead of being shocked at this conclusion, Renan seems to find in it something peculiarly sweet to his æsthetic sensibilities; and, with that curious sentimentalism which gives to all his writings an air of indifference to truth and of essential un-

* I have not deemed it necessary to discuss the notion which formerly found some advocates, that Jesus had not died, and that his supposed resurrection was only a recovery from a swoon. The manifold difficulties to which this hypothesis is exposed have led to an almost unanimous rejection of it as incredible. Professor Huxley attempted to revive the hypothesis in a paper which he read before the Metaphysical Society, "in which he argued that there was no valid evidence of actual death having taken place." *Life and Letters*, vol. i, p. 342. The paper seems not to have been published. His position is interesting chiefly as indicating his recognition of the weakness of the hypothesis more commonly adopted by those who do not accept the resurrection as historic.

† *Life of Jesus*, ch. xxvi.

morality, he exclaims, "Divine power of love! sacred moments in which the passion of a hallucinated woman gives to the world a risen God!"

The first suggestion of the resurrection came from Mary Magdalene; but others were destined soon to share the same delusion.* So contagious, indeed, was Mary's faith and enthusiasm that some of the disciples imagined they saw the risen Lord that same day in Jerusalem. But the visions became more frequent when, a few days later, the apostles returned to Galilee. They lingered around the beautiful lake, where every village and every hillside was linked by fond association in their minds with the memory of Jesus, where the blue waters seemed still to mirror his serene face, and the very air seemed still pulsating with the music of his voice. As they lingered amid those scenes, their minds fell more and more under the spell of those fond memories, till one and another seemed to himself to see the loved form of the Master and to hear his voice. And the hallucination of some became the faith of all the disciples.

But, if the appearance of the risen Lord was a delusion or hallucination, it was certainly a most peculiar one. The natural history of hallucinations has been extensively studied, and their laws are pretty well understood. Somewhat of the history of this particular delusion, if it was one, we can gather from the New Testament narratives. The honesty of those narratives is unimpeachable. Even on the theory of hallu-

* Renan, *The Apostles*, ch. i–iii.

cination, we may assume that we have a substantially veracious, though uncritical, narrative of the subjective experiences of the disciples. So far as we can thus trace the history of this delusion, it seems to have been of a very exceptional sort.

A delusion is apt to be preceded by a state of strongly excited expectancy. The person sees what he has been made to believe he will see. But in this case there was no such expectation. The death of Jesus plunged the disciples into utter despair. Whatever he had said about his death and resurrection had been so completely at variance with all their prepossessions that it had made no impression on their stolid unbelief. When Mary found the sepulcher empty, she could only think that some one had taken away the body and laid it she knew not where.* The reports of the women to the apostles "seemed to them as idle tales, and they believed them not."† The mental attitude of the disciples was the very opposite of that state of expectant attention in which hallucinations most frequently originate.

A delusion most commonly affects only a single individual. Shakespeare is psychologically correct in making Banquo's ghost invisible to the rest of the company, though profoundly real to the guilty fears of Macbeth. But in this case the delusion affected simultaneously considerable numbers of persons—in one instance over five hundred,‡—including, doubtless, men of all varieties of temperament, hopeful and de-

* John, xx, 13. † Luke, xxiv, 11. ‡ I Cor., xv, 6.

spondent, imaginative and prosaic. All saw the same blessed vision. In the cases in which delusions have become epidemic and affected considerable numbers of persons, they have generally had a history extending over some months or years, in which they have gradually become prevalent and as gradually declined. In this case there was no such gradual development. The faith of the apostles, excepting Thomas, in the reality of the resurrection was established before the close of the Easter Day. The appearances reported are few in number, and all were comprised within the space of forty days. After that short period the risen Jesus vanishes forever. Whatever fantastic visions appeared to the imagination of more or less fanatical Christians, the risen Jesus walked the earth no more. The delusion vanished as suddenly as it came. The dream was dreamed out in forty days.

A delusion generally affects a single sense—most commonly sight or hearing; and the delusion of sight is shown to be such by the failure of the tactual sensations which would be experienced if the supposed objective cause of the visual sensations were real. When the hand cannot clutch the air-drawn dagger, the dagger is only "a dagger of the mind."* In this case, apparently, the tactual sensations corresponded with the visual. The transparently artless narratives seem to indicate that all unconsciously the disciples tried the very experiment which a physiological psycholo-

* An interesting illustration of this principle is seen in the case of Mrs. A., reported in Brewster's *Letters on Natural Magic*, quoted by Huxley, *Lessons in Elementary Physiology*, 6th edition, Appendix B.

gist would have suggested. The women, says Matthew, "took hold of his feet."* Had the visual sensation been a delusion, the hands would have grasped only air. To the terrified apostles, who "supposed that they had seen a spirit," Jesus said, according to Luke's report, "Behold my hands and my feet, that it is I myself: *handle* me and see; for a spirit hath not flesh and bones, as ye see me have." And John's faithful memory has preserved the story how the doubting Thomas had his doubts set at rest when Jesus gave him the evidence which he demanded—"Reach hither thy finger, and behold my hands; and reach hither thy hand, and thrust it into my side."†

I realize fully the difficulties which the thought of the present age must find in accepting the faith in the resurrection. I see the solemn procession of the generations marching into

> "The undiscovered country from whose bourn
> No traveler returns."

---

* Revised Version—here, as usually, more accurate than the Authorized Version.

† The view which Keim has presented in his *Geschichte Jesu von Nazara*, agrees with that of Renan and others in making the appearances of the risen Jesus to the disciples purely subjective. From an ethico-theological standpoint, however, Keim's position differs very widely from Renan's. Keim holds that the vision of the risen Lord came to the disciples by a special divine influence exerted upon their souls, for the purpose of convincing them of the continued life of their Master, and of the triumph of his kingdom in spite of seeming defeat. The vision was, then, a genuine miracle, though it was a miracle in the subjective sphere of consciousness, and not in the objective sphere of material things. There is, perhaps, no very serious objection *a priori* to the notion of that sort of a miracle. The effect upon the minds of the disciples would have been the same as if the miracle had been in the objective sphere. But the critical process by which Keim reaches his conclusion seems arbitrary and unreasonable. He rejects the narratives in the Gospels as worthless, holding that Paul's statement in the First Epistle to the Corinthians is the sole trustworthy authority for the fact of the resurrection. I believe that a sound criticism must maintain the substantially historic character of the Gospel narratives, in spite of discrepancies in details, and even if some

I realize the improbability of an exception to a generalization sustained by so immense a mass of accordant experience. But, when I think of the alternatives to belief in the resurrection, they all seem so much more improbable that I find it easier to accept the one mystery which explains all mysteries. To believe that the faith in the resurrection was a delusion so contradicting all psychological laws, or a myth which was fully developed in a single day, or a falsehood perpetrated by the disciples to bring upon themselves imprisonment and death—to believe that the system of religious faith which has created a new and nobler civilization had its origin in fraud or self-deception—taxes credulity more than to believe that Jesus rose from the dead.

If we accept as probably historic the resurrection of Jesus, the obvious corollary is suggested, that miracle is part of the divine plan of revelation,—that the Ruler of the universe, in revealing himself to mankind, has seen fit to authenticate that revelation by extraordinary events in the physical world. From this point of view it appears probable that the miracle of the resurrection of Jesus has not been an isolated instance, but that other miracles more or less numerous have attended the critical epochs in the history of revelation.

This suggestion finds confirmation in the peculiar chronological distribution of miracles in sacred history. With very few exceptions, the miraculous nar-

admixture of legendary elements is conceded. Of course, Keim's theory falls to the ground if the Gospel narratives are trustworthy.

ratives of the Bible are included in three great groups. One series of miracles is found in connection with the Exodus, and the inauguration of the Mosaic law, and the establishment of the Jewish church and theocratic state. A second series of miracles occurs in connection with the inauguration of the prophetic ministry under Elijah and Elisha, and the great conflict in the kingdom of Israel between the religion of Jehovah and that of Baal. The third and greatest series of miracles attends the introduction of Christianity under the ministry of Jesus himself and the apostles. Now, if stories of miraculous events are simply the product of the imaginative tendencies of the Hebrew mind, it is difficult to see any adequate reason for this limitation of miracle to three well-defined groups. We should expect them to be more uniformly distributed through sacred history. Especially we should expect the lives of peculiarly interesting and picturesque characters to be adorned with legends of miracles. Abraham, the father of the faithful and the friend of God, is a very striking figure in sacred history. David, the sweet singer and shepherd king, is the very incarnation of romance and poetry. And, if the stories of miracles in the Bible were simply the product of the uncritical imagination which transforms history into legend, we should expect the biographies of Abraham and David to be luminous with the glory of miracle; but we find scarcely a trace of miracle in the life of either of these men. The limitation of miracle to three great series, marking respectively the Mosaic, the prophetic, and

the Christian dispensation in the history of revelation, finds its most reasonable explanation in the belief that miracle forms a part of the divine plan of revelation, and that each of the great critical stages in the development of a progressive revelation has been marked by more or less numerous miracles.

The acceptance of this conclusion by no means requires us to accept as historic all the miraculous narratives of the Old Testament or even of the New Testament. While it is probable that each great epoch in the history of revelation has been marked by actual miracles more or less numerous, it is not unlikely that with those narratives of miracle which are truly historic others may have come to be associated which are legendary. It is altogether probable that legendary elements in considerably large degree are mingled in the Old Testament history, and in less degree even in the New Testament history. Each miraculous narrative in the Bible, then, must be subjected to a distinct critical investigation. They differ very widely in their degree of probability both *a priori* and *a posteriori*. Some miracles are characterized by a dignity, and a congruity with the revelation of truth which they are supposed to authenticate, that commend them strongly to our belief. Others are trivial or grotesque, and unaccompanied by any revelation of moral or religious truth which seems to constitute an adequate reason for their existence. As the different miracles of the Bible differ widely in the degree of their *a priori* probability, so they differ widely in the value of the testimony by

which they are supported. In the case of the resurrection of Jesus, we have found unquestionable evidence of contemporary belief in its reality. In the case of many of the Old Testament miracles, there is no approximation to contemporary testimony.

As an illustration of a miracle which seems to have very little claim to acceptance as a historic fact, we may take the case of the sun and moon standing still in obedience to the word of Joshua.* It is enormously improbable *a priori* that the rotation of the earth was suspended in order that Joshua might have a few more hours of daylight wherein to slaughter a few more of the Amorites. Only on very strong evidence could such an allegation find credence. The story occurs in a book which nearly all recent critics regard as composite, documents of different ages having been compiled by a later editor to form a continuous narrative. Nothing very definite is known in regard to the authorship and the date, either of the original documents or of the compilation. In this anonymous and dateless compilation, the command of Joshua to the sun and moon is introduced as a quotation from another dateless and anonymous book, the Book of Jasher. Of this latter book we know nothing beyond the fact that it is twice quoted in the extant books of the Old Testament.† The other quotation in the Old Testament attributed to the Book of Jasher is the elegy which David is said to have composed after the death of Saul and

* Josh., x, 12–14.

† There may be a third quotation from the Book of Jasher in I Kings, viii, 12, 13. See Hastings, *Dictionary of the Bible*, art. *Jasher*, by W. H. Bennett.

Jonathan.* The Book of Jasher, then, is certainly not earlier in date than the time of David; how much later, we have no means of knowing. It is evident then that we have nothing that makes any approach to the character of contemporary testimony in regard to the incident in question. Moreover, the Book of Jasher seems to have been a collection of poems; and the poetic character of the language in the present case suggests the probability that the standing still of sun and moon was originally only a figure of speech. The sun always stands still for him who works with heroic enthusiasm to accomplish what he believes to be a divine mission. It seems likely that a more prosaic compiler mistook the poet's figure for historic fact. But, whether that be the true explanation of the genesis of the narrative or not, there is no reason to justify a belief that the rotation of the earth was suspended.

For another illustration of the same sort we may take the case of Jonah. The story of the whale or sea monster is certainly too grotesque to have any *a priori* probability. By its historic allusions and by its linguistic characteristics, the Book of Jonah is shown to belong to a date at least two hundred years subsequent to the time when the prophet is supposed to have lived. The non-miraculous parts of the narrative are only surpassed in improbability by the miracle itself. In all probability the narrative was originally intended to be symbolic; the whole story being a sort of parable, whose moral teaching is a protest against the narrow-

* II Sam., i, 19-27.

ness of prevalent Jewish conceptions as to the character of Jehovah and his religion. The teaching of the book is indeed an anticipation of Paul's assertion that God is not "the God of the Jews only" but "of the Gentiles also." No utterance of Hebrew prophecy breathes a spirit more truly and nobly Christian. Whether the symbolic narrative has any foundation in fact, and, if so, what that foundation may have been, are questions to which no definite answer can be given. The conjecture is not without plausibility that the psalm of praise attributed to the prophet, commemorating his deliverance from the perils of the sea, forming now the second chapter of the book, may have been written in celebration of an escape from shipwreck.* But, whatever opinions we may hold as to the literary character and as to the origin of the Book of Jonah, there is surely no sufficient ground for believing that the prophet was swallowed by a sea monster, kept alive for three days in the alimentary canal of that creature, and subsequently discharged alive upon the shore.

It must be recognized even in the life of Jesus that various miraculous events are attended by unequal degrees of evidence. The contrast in this respect is very striking between the two miraculous events which have come to be included in the creeds of Christendom—the virgin birth and the resurrection. The strength of the evidence for the resurrection we have already considered. The belief in the resurrection was the very corner-stone upon which historic Christianity

* Driver, *Introduction to the Literature of the Old Testament*, p. 304.

was built: the very existence of the church is proof of contemporaneous belief in the resurrection as historic. The assertion of the resurrection formed the staple of apostolic preaching. The fact is asserted or implied on almost every page of the Acts and Epistles. To dissect out from the New Testament the story of the resurrection would be to cut the book into fragments. On the other hand, the story of the virgin birth is referred to only in the opening chapters of Matthew and Luke—chapters which seem to have a somewhat different tone and character from the remaining parts of the same Gospels. If those opening chapters of Matthew and Luke were dropped out, not a line elsewhere in the New Testament would thereby require alteration; for nowhere else in the New Testament is there an assertion or an obvious and unambiguous implication of the virgin birth. I do not say that the miraculous birth is not a historic fact. A strong argument may be made for its historic truth. But the evidence in its favor is incomparably less strong than the evidence for the resurrection; and, with perfect consistency, a critic may believe that the resurrection is a historic fact, and the miraculous birth a legend. Accepting the proposition that miracle is a part of the divine plan of revelation, we can find no difficulty in accepting as historic most of the miracles of Jesus related in the Gospels. They are in general so dignified, so full of moral significance in themselves, so appropriate to the religious teaching which they authenticate, as to commend themselves strongly

to our belief. Yet the critical mind can hardly escape the feeling that a few of the miraculous stories in the life of Jesus have something of a legendary aspect. The story of the piece of money that Peter found in the mouth of the fish* has a grotesque aspect quite different from that of most of the miracles of Jesus; and a person of scientific and critical habit of mind cannot easily believe that a legion of devils actually entered into a herd of swine.†

My object in referring to these instances has been to indicate the general attitude in which the study of the miraculous narratives of the Bible must be conducted. The recognition of miracle as part of the divine plan involves the probable occurrence of miracles more or less numerous at each critical stage of revelation; but it must be the work of a criticism at once fearless and reverent to examine independently each one of the Biblical narratives and estimate its degree of probability. Some miracles can be very confidently accepted. A critical examination of others seems to require their rejection as unhistorical. In regard to a large number, the wisest attitude may probably be a suspension of judgment.

There can be no more pernicious teaching than that which is offered by many good men in the most devout spirit and with the best of motives—the teaching that all the miracles of the Bible must stand or fall together. The great strength of the evidence of the res-

---

* Matt., xvii, 24–27.
† Matt., viii, 28–34; Mark, v, 1–20; Luke, viii, 26–39.

urrection of Jesus renders reasonable not only the acceptance of that miracle, but also the acceptance of other miracles in themselves supported by far less of evidence; but the Christian apologist must beware of carrying this line of argument too far. There is a limit to the acceptance of beliefs, otherwise improbable, as corollaries of the belief in the resurrection of Jesus. Strong as is that foundation, it may be crushed by building upon it too heavy a superstructure. There is no more effective way of destroying the faith in Christianity than to teach men that we cannot accept the resurrection of Jesus without accepting as equally historic the standing still of sun and moon and Jonah's sojourn in the whale.

The subject of ecclesiastical miracles and that of pagan miracles require no extended discussion. The numerous miracles with which the lives of medieval saints have been adorned, are for the most part trifling, grotesque, or ridiculous. They inculcate no moral lessons; they teach no doctrine except that of the eminent saintship of the person about whom they are related. The lives of the saints, in which they are related, are generally of so sentimental a character as to be utterly untrustworthy, and in most cases there is no contemporary testimony.* If possible, still more unworthy of credence are most of the miracles or prodigies connected with the lives of pagan saints and

* Some of the remarkable stories related of the saints are doubtless historic, but not miraculous. There is no reason to doubt that Saint Francis of Assisi had the *stigmata* in his hands and feet. The same phenomenon has appeared in unquestionable modern instances, and admits of physiological explanation. See Carpenter, *Principles of Mental Physiology*, p. 689.

heroes. The contrast between these pagan and ecclesiastical miracles, and the great majority of the miracles of the New Testament, was clearly recognized in the remark of Niebuhr in regard to the New Testament miracles, that "it only requires a comparison with legends, or the pretended miracles of other religions, to perceive by what a different spirit they are animated."*

Nor is there need of any extended discussion of so-called modern miracles, such as those of faith-healers and Christian Scientists. The cures wrought are often incomplete and temporary. A large share of the cases are cases of those obscure nervous diseases which, as every student of physiology and psychology knows, are very likely to be temporarily mitigated or permanently cured by the influence of strong mental impressions upon the nervous system. Such cases are often cured by spiritualists or mesmerists, by mental suggestions communicated by a physician in whom the patient has confidence, or by purely accidental causes like an alarm of fire in a house in which a bed-ridden patient is lying. While we must hold fast to the assertion of Hume,† that "whatever is intelligible and can be distinctly conceived, implies no contradiction, and can never be proved false by any demonstrative argument, or abstract reasoning *a priori*," and while therefore the possibility of the occurrence of very extraordinary events at any time in the past or future must

* *Memoir of Niebuhr*, American edition, p. 236; cited by Fisher, *Grounds of Theistic and Christian Belief*, revised edition, p. 432.

† Cited on page 354.

be conceded, the only miracles which can be considered as reasonably well attested are those which mark the successive stages of that progressive revelation which has culminated in Christianity.

And now we must ask, what is the significance of miracle? Assuming that miracles have occurred in connection with the introduction of particular phases of religious teaching, we must ask, what purpose have those miracles served? In the first place, miracles attract attention to the religious teacher by whom they are performed. The multitudes followed Jesus and listened to him, because they saw his miracles. Miracles, then, arouse attention and secure a hearing for the teacher. But the significance of a miracle is far more than merely to excite attention. A miracle serves to authenticate as authoritative the teaching with which it is associated. The significance of miracle was expressed in the words of Nicodemus:* "Rabbi, we know that thou art a teacher come from God; for no man can do these miracles that thou doest, except God be with him." The divine power revealed in the acts of Jesus attested the divine authority of the words of Jesus. The thought of Nicodemus would require somewhat of restatement to bring it into accord with our philosophic views of divine immanence and the constancy of natural laws; but the argument in its essential meaning is still valid. If the Ordainer of the whole system of natural law has so planned that system as to make a startling event, inexplicable to

---

* John, iii, 2.

human knowledge, and contradicting the inductions founded on previous experience, occur in coincidence with religious teaching of extraordinary significance, it must be assumed that the coincidence is designed, and that the design of such coincidence is the authentication of the teaching as authoritative. The miracles of Jesus, then, not only command attention but command belief.

Such, then, was the office of the miracles of Jesus in their time; but the question remains, have those miracles any value to us? Now that Christianity has found a wide and sympathetic hearing, and has commended itself to the judgment of mankind by its intrinsic beauty, its accord with the highest philosophy, and its adaptation to the moral needs of humanity,—now that it has become embodied in the institutions of Christian civilization,—are the old miracles of any value to us? Did miracle serve only to introduce Christian faith when Christian faith was a stranger to the world, or does it serve still to support Christian faith? Was miracle only a scaffolding, which was necessary when the temple of Christianity was in process of building, but which might well be pulled down or allowed to fall into ruin when the edifice was finised? or is it still a structural element of the building, a pillar by which in part the building is supported? Not a few devout and thoughtful people have believed that the remarkable phenomena which appeared in connection with the teaching of Jesus had their mission in introducing the teaching of Jesus to the world, but

that they are of no value to us, and that it is of no consequence whether the supposed events were historic facts or illusions. Unquestionably there is a truth underlying this line of thought—the truth that other phases of Christian evidence have developed themselves into greater relative importance with the progress of Christian thought and life, and that the evidence afforded by miracle is of less relative importance than at the beginning of Christianity. Yet I believe that the evidence of miracle is still valid and still needed. We stand in an upper room in Jerusalem, and listen to the words with which the young Prophet of Galilee comforted his disciples on the last night of his life. "Let not your heart be troubled: ye believe in God, believe also in me. In my Father's house are many mansions: if it were not so, I would have told you. I go to prepare a place for you. And if I go and prepare a place for you, I will come again, and receive you unto myself; that where I am, there ye may be also." Beautiful words, in their sweet simplicity, and in their accord with our highest moral sentiments, our holiest aspirations! Words so beautiful ought to be true. But are they the words of one who speaks with authority and whose word can be trusted? or are they only the sweet dreams of a spirit too pure and gentle for this hard, rough world? To us, as to those disciples who heard him, the evidence of the authority of his teaching is found in the fact of his resurrection. It was not so much the beautiful farewell address to the disciples, as the empty sepulcher on the Easter

morning, that "brought life and immortality to light." The words which the church reads over the graves of its dead, and which bring to a dying world the brightest hope that it has ever known, are taken from the fifteenth chapter of the First Epistle to the Corinthians—the chapter in which we have the earliest and the most certainly authentic record of the fact of the resurrection of Jesus.

REVELATION AND THE BIBLE

In the controversies attending and following the Reformation, Protestants were led to emphasize the authority of the Bible, in contrast with the Roman Catholic doctrine of the authority of the church. One unhappy result of these controversies was an extravagant and superstitious notion as to the relation of the Bible to the Christian revelation. That exaggerated estimate of the position of the Bible found expression in the phrase oft repeated as a watchword of Protestantism, "the Bible the religion of Protestants." Certainly the Bible is not our religion. Christianity is a series of historic facts, a system of theological doctrines, a life of faith and consecration. The Bible contains indeed a record of those facts, teaches those doctrines, and tends to inspire the soul to live that life; but in no sense is the Christian religion synonymous or coextensive with the Bible. The Bible is not the revelation, but the record of the revelation; and the revelation has always preceded the books in which it has been recorded. Abraham and Moses had no

Bible; the Christian church lived and grew and developed in theological thought and religious life for more than half a century before the latest book of the New Testament was written, and for a still longer time before those books were collected to form the canon of the New Testament.

The central truth of revelation is that God has spoken *πολυμερῶς καὶ πολυτρόπως*—"by divers portions and in divers manners."* We need not suppose that he has spoken to Jews and Christians alone. He has been the God "not of the Jews only," but "of the Gentiles also;" and we may welcome the truth that has been proclaimed by pagan saints and sages as a genuine revelation of God.† Nevertheless, the supreme manifestation of God to man is in that historic series of revelations which culminates in the appearance of Jesus Christ. God has revealed himself in human life—in subjective experiences, and in objective facts of individual and national history; in the visions of divine truth which have come to the soul of the seer and saint; in Abraham's wandering into exile to found a monotheistic family and a theocratic state, in the Exodus and the Mosaic law, in the ritual of tabernacle and temple, in prophetic word and prophetic symbol; and preeminently in the sinless life, the unique teaching, and the works of love and power of Jesus Christ, and in the great facts of his death and resurrection. He revealed himself in the life of the church of the apos-

* Hebrews, i, 1, Revised Version.

† So Justin Martyr recognized Socrates as divinely enlightened. *Second Apology*, ch. x.

tolic age, and reveals himself continuously in the life of the church of all ages.

> "Slowly the Bible of the race is writ,
> And not on paper leaves nor leaves of stone."

Inspiration is not identical with revelation. Inspiration is the influence of the divine Spirit upon a human soul. It is only by a sort of metonymy that we can predicate inspiration of a book. An inspired book can mean nothing other than a book written by inspired men. There is nothing on earth that can be inspired excepting human souls. In the beautiful liturgy in which so largely the devotion of the English-speaking world has found expression, men are taught to pray, "Cleanse the thoughts of our hearts by the inspiration of thy Holy Spirit." But the multitude of worshipers who have joined in that prayer, and in whose lives it has found an answer, have neither expected nor received new revelations of religious truth. The true Light "lighteth every man that cometh into the world." Inspiration in some degree is the privilege of every human soul that does not willfully close its doors against the heavenly Guest; and to all those who are called in the providence of God to positions of peculiar importance and responsibility, may come a special inspiration to fit them for the work they are called to do. The true preacher prays for and receives an inspiration that gives power to his arguments and appeals. The missionary and the reformer are inspired for their conflicts with heathenism and with error. And so to prophet and evangelist and apostle came inspiration in

form and measure to qualify them for the service which they were to render in the working out of a historic revelation. The inspiration which in all subsequent ages of the church has come out of the Bible, is proof of the inspiration that went into the Bible.

It is needless to seek for diagnostic characters which will distinguish the inspiration of the men of the Bible from the inspiration of later workers in the church—the inspiration of Isaiah and Paul from that of Savonarola and Wesley. The truth of the divine immanence well-nigh makes void the distinction of natural and supernatural in the activities of God in the physical universe. The supernatural can mean no more than the uncommon or unusual, in a universe which is all divine.* In like manner, a true philosophy of the moral universe will recognize the universality of inspiration; and so the significance of the inspiration of prophet and evangelist and apostle is not in that their inspiration differs *per se,* qualitatively or quantitatively, from that of God's workmen of later times, but simply in the fact that in the providence of God they were called to the work of expounding or recording the successive stages of progressive revelation. The historical relation of their work to the divine plan, not anything in itself peculiar in their experiences of the divine life, gives to their work a unique significance and value.

---

* "The only distinct meaning of the word 'natural' is stated, fixed, or settled; since what is natural as much requires and presupposes an intelligent agent to render it so, i. e., to effect it continually or at stated times, as what is supernatural or miraculous does to effect it for once." Butler, *Analogy of Religion.* It is noteworthy that Darwin quoted this passage as one of the mottoes opposite the title page of the *Origin of Species.*

We have noticed some of the contradictions between the Scripture text and the facts and probabilities of science, which are irreconcilable with a belief in the inerrancy of the Bible. But science is not alone in contradicting the dogma of the inerrancy of the Bible. There are historical inaccuracies in the Bible as unquestionably as scientific errors, and in multitudes of cases various parts of the Bible contradict each other. Surely the Bible is not inerrant, nor is there any reason why it should be. It is not itself the revelation, but it is a record of the revelation which was given in human life and history. For the purposes of such a record, inerrancy is not necessary, but only a substantially true representation of the facts of revelation, and a high spiritual conception of its ethical and religious content.

When we recognize the progressive character of revelation, we find no stumbling-block in the imperfect conceptions even of moral and religious truth set forth in the Bible. Neither the theology nor the ethics of the Christian dispensation could be taught to the Jews of the time of the Exodus. The Mosaic law of divorce is not the Christian law. The ethical standard of the imprecatory Psalms is not that of the Sermon on the Mount. The religious life revealed in the Book of Judges is not the same that irradiates the Gospel of John. Like the pillar of cloud and fire in the wilderness, God's revelation marches through the centuries before his people, never so far in advance as to be out of sight, always far enough in advance to keep devout and obedient souls moving forward.

Thus we recognize in what sense the Bible is authoritative. Since inerrancy or infallibility can be predicated neither of the Bible as a whole, nor of any particular part of the Bible, no single sentence of the Bible can be in itself authoritative. The use of detached sentences as proof-texts, without regard to the context, by which all sorts of absurd and abominable doctrines have been supposed to be proved by the authority of the Bible, rests upon principles radically false. But, when the Bible is viewed as a record of a progressive revelation, and its component parts are studied with a literary and historic sense that places us in the standpoint of the various writers, the general significance of the revelation which it records is intelligible to the devout and candid mind.

When we come to think of the Bible, not as a magical book, made all at once, and dropped upon the earth like the heaven-descended idols of pagan superstition, but rather as the record of the human life and experience through which God was revealing himself; when we feel in its living pages the pulsations of the hearts of men who were struggling with the evil of their times, and striving to live the truth which had been revealed to them; when we recognize the intense humanity of the Bible; it acquires for us an interest which the impersonal and inerrant book of post-Reformation dogma could never have. Like Him whose story it records, the Bible is

> "Most human and yet most divine,
> The flower of man and God."

PART III

GENERAL STATUS OF CHRISTIAN EVIDENCES

PART III

General Status of Christian Evidences

In the period of somewhat more than a century since the publication of the classical works of Butler and Paley, there has been a pretty radical change in the method of apologetics. This change has been in part necessitated by the change in the prevalent form of unbelief. In the eighteenth century the prevalent form of unbelief, at least in England, was deism; and the great defenders of Christian faith shaped their arguments with reference to the position of their antagonists. The whole argument, for instance, of Butler's "Analogy" is that the difficulties in the way of believing in the divine authorship of Christianity are not other in kind nor greater in degree than the difficulties in the way of believing in the divine authorship of nature. Accordingly, presuming that his readers were ready to believe in a divine Author of nature, he called upon them to believe in a divine Author of Christianity. Very different is the prevalent phase of unbelief to-day. In the thought of this age deism is thoroughly discredited. No religious or philosophic system ever paid so poor interest on the investment of faith required for its acceptance as deism. If a man

is able to stretch his faith so far beyond the reach of sensuous experience or of mathematical demonstration as to believe in a personal God, it seems absurdly foolish to forego the comfort and the inspiration which lie in the belief in a Heavenly Father, and to make his personal God the worthless *caput mortuum* of deism. The unbelief of to-day refuses either to affirm or to deny the personality of the ground of all existence, maintaining that the question transcends the reach of human faculty, and that the only philosophical attitude is the holding of opinion in abeyance. Agnosticism is the unbelief of to-day; and arguments addressed to the deist make no impression upon the agnostic.

But while, outside of the pale of Christianity, there is less disposition now than in the eighteenth century to concede or accept the existence of a personal God, there has been a wonderful change in the attitude of non-Christian thought toward the person of Jesus Christ. A profound reverence for the character of Jesus is almost as characteristic of the heretical thought as of the orthodox thought of our time. Compare the scurrilous blasphemy of Paine with the tender sentimentalism of Renan, and you will find a striking illustration of this change of feeling toward Jesus. In view of this twofold change in the character of prevalent non-Christian thought, it is not strange that Christian apologists have come to ask themselves the question whether the evidence of Christianity is not stronger than the evidence of theism, and whether, in arguing primarily for theism and appending Chris-

tianity thereto as a corollary, they have not failed to show the real strength of the evidence of the truth which they have sought to defend.

But the change in the order and perspective of apologetics is not due alone to the change in the prevalent form of disbelief. It is due chiefly to a change in the general character of the thought of the age. Believers and disbelievers in Christianity float on the same stream of the world's thought, and feel the impulse of the same current. The thought of the eighteenth century was bound at all hazards to be systematic; the thought of to-day cares not whether it is systematic or not. Eighteenth-century investigators were unwilling to march into the territory of the unknown, except in the most elaborate and punctilious military order. More recent investigators deploy as skirmishers, and are content if, by the most irregular scientific bushwhacking, they can bring in a few captive facts. Eighteenth-century thought on every subject aimed to lay down first principles which were axiomatic or capable of somewhat easy proof, and then to proceed to ulterior conclusions by a rigorous process of deduction. The thought of to-day is chiefly inductive. It conjures up an hypothesis, and tests it by its coincidence or lack of coincidence with facts. Only exceptionally are its hypotheses capable of verification by some crucial experiment or observation which absolutely excludes all alternative opinions. In the vast majority of cases its hypotheses find a provisional verification in that the *tout ensemble* of phenomena appear to accord with the

chosen hypothesis more fully than with any alternative one. It is a striking illustration of this change in intellectual habit that those sciences whose work is largely mathematical and deductive attained a condition of relative maturity much earlier than those sciences whose work is mainly observational and inductive. Newton's "Principia," the epoch-making masterpiece of deductive science, belongs to the close of the seventeenth century. Darwin's "Origin of Species," the epoch-making masterpiece of inductive science, belongs to the middle of the nineteenth century.

This change in the general habit of thought of the times changes naturally the order and perspective of apologetics. Eighteenth-century apologetics had to be systematic and consecutive. It must make theism the fundamental proposition, and proceed to build the evidence of Christian revelation upon the foundation of theism. But the consecutive method, although perfectly adapted for subjects in which demonstration is possible, is essentially ill adapted for subjects in which the reasoning can be only probable. In geometry, we can start with axioms which may be accepted as substantially certain, and Proposition 1 may be deductively inferred from axioms and definitions. In the demonstration of Proposition 2, we may use Proposition 1, as well as the axioms and definitions, and so on through the series. Essentially the same virtual certainty that marks the axioms at the beginning is carried forward to the end. But this mode of procedure is not so effective in dealing with subjects where

demonstration is impossible. If we have two premises, the probability of whose truth may be expressed in each case by the fraction $\frac{3}{4}$, the resultant probability of the conclusion, on the assumption that these premises include all the evidence for the truth of the conclusion, has a value of only $\frac{9}{16}$. If we proceed to use that conclusion as a premise for further consecutive reasoning, combining it with another proposition which is only probable, it is evident that the force of the probability is further weakened; and thus the probability is reduced at every step until the argument comes to be of utterly insignificant value.

But the traditional presentation of Christian evidences was not merely subject to the weakness that is inherent in any attempt at a consecutive presentation of evidence on a subject which does not admit of demonstration. The argument came to be burdened with a gratuitous accumulation of inconsistencies. The outline of procedure in apologetics has, in fact, often been substantially as follows:—Proposition 1. There is a God, because the religious intuitions of humanity affirm that there is a God. Proposition 2. There is need of revelation, because the religious intuitions of humanity are so conflicting and uncertain that they are good for nothing. Proposition 3. Christianity is a revelation from God, because the religious intuitions of humanity approve it. If the student who has reached that stage in the argument has any lingering faith in either God or man, it may be matter for thanksgiving.

From a consecutive, we must turn to a cumulative, presentation of the evidence. Our apologetic must conform, not to the consecutive and deductive model of eighteenth-century thought, but to the hypothetical and inductive model of present thought. The verification of belief must be sought, not in a single invincible line of argument, but in the conformity of the belief to an assemblage of multitudinous phenomena—in the convergence of lines of evidence drawn from different and apparently unconnected classes of facts. It was remarked long ago by Lord Bacon that the confirmation of scientific theories depends upon the mutual coherence and adaptation of their parts, whereby they sustain each other like the parts of an arch or dome.* No finer example of this dome of hypothesis is afforded in the history of human thought than in the case of that theory of evolution whose discovery and verification was the great intellectual achievement of the nineteenth century. Do we believe in evolution because organs appropriated to different uses may yet be homologous in structure? or because the bodies of animals and plants are full of rudimentary organs? or because the successive stages of development of the embryo are in large degree approximate recapitulations of the series of earlier and lower species? or because the geological record shows in successive ages a gradual expansion of organic types, a progressive ascent to forms of higher grade, and a gradual approximation to the

* *Theoriarum vires, arcta et quasi se mutuo sustinente partium adaptatione, qua quasi in orbem cohærent, firmantur.*

fauna and flora of to-day? or because successive faunas and floras in the same region reveal a similarity which suggests community of origin? or because the boundary lines of all groups recognized in zoological and botanical classification grow more indefinite with increasing knowledge? No. Not one of these classes of facts would be sufficient to establish a reasonable probability for the doctrine of evolution. The probability of the doctrine lies precisely in the fact that all these different and independent lines of argument converge to one conclusion—that the idea of evolution gives an intelligible and unitary significance to all these classes of facts which are otherwise unconnected and meaningless. In like cumulative form must be exhibited the convergence of evidence toward the truth of Christianity. Nature, with its myriad adaptations and its all-pervading order and law, its omnipresent aspect of intellectuality; man, with his inextinguishable sense of responsibility and his irrepressible religious aspirations; the historic Jesus, with his stainless life and his unparalleled teaching; Christianity, with its doctrines so sublime, so comforting, and so ennobling; Christendom, with its vast philanthropies and its new type of civilization—these constitute an *ensemble* of facts which must be rationally accounted for. The idea of a Heavenly Father revealed in Christ Jesus gives to them all an intelligible and unitary significance.

The real evidence, then, for Christianity is not found in any one line of argument, but in the convergence

of all lines. The dome rests, not on one pillar, but on many pillars. But, although the dome must be supported on every side, and its strength is dependent upon the many-sidedness of its support, it is not necessary that all the pillars should be equally strong, or should sustain equal portions of the weight of the structure. And, while the cogency of Christian evidence consists in the convergence of various lines of evidence, it does not necessarily follow that those various lines of evidence are equally important. Nor will the comparative importance of different lines of evidence be the same in different ages.

Of the various convergent lines of evidence, there are two which are especially impressive to the thought of the present age. One of these is found in the effects of Christianity. And here we come to formulate the unconscious logic of the faith in Christianity which for most of us is associated with the tenderest memories of childhood. The noble lives and characters of those who in our childhood were nearest and dearest to us, were a proof of the truth of that religion which expressed itself in life and character. It is in this view an inspiring thought that the duty of the Church is not merely to expound, but to make, the evidence of Christianity. The world beholds the daily miracle of souls dead in sin rising into the life of goodness, and, as in the ancient days, the multitudes glorify God, who has given such power unto men.*

But, of all evidences of Christianity, to modern

* Matt., ix, 8.

thought the most impressive is found in the personality of Jesus Christ. Biblical criticism, while it has contradicted many traditional opinions in regard to the date and authorship of the books of the Bible, has pretty thoroughly established the early date of enough of the New Testament to show that the portrait of Jesus is a contemporary portrait. The affidavits of the original witnesses are certified by the notarial seal of modern criticism. The Jesus whose unique character was an oasis of heaven in the sin-blasted desert of earth—teacher of a morality unapproached in its stern purity, yet friend of sinners—incarnation of self-sacrifice, yet free from taint of asceticism or stoicism—bearing in sympathetic woe the burden of a world's sin, yet making the wedding feast more glad by his presence, and condescending in his last agony to ask the faint alleviation of a drink to moisten lips and tongue—brave, patient, tender to all, sympathizing with the sorrows of every human soul, though none could sympathize with him—was no dream that tender and saintly souls dreamed when the simple outlines of fact had grown dim in tradition, but was painted from life. Through the historic Jesus we are led to faith in the divine Christ. Christ himself is not only the inspiration of Christian life and the center of Christian dogma, but also the foundation of Christian apologetics. "Ye believe in God, believe also in me," said the Master to his perplexed, doubting, sorrowing disciples, while he yet waited for the glorification which could come only through the cross and the sepulcher.

Enthroned by the reverent love of humanity, inspiring the world's highest thought and noblest life, Christ might say to the doubters of our age, "Ye believe in me, believe also in God."

And now we are prepared to answer the question which we proposed to ourselves in the beginning of our discussion—can the faith which first breathed in the unscientific atmosphere of the first century survive in the scientific atmosphere of the twentieth century?

We have traced the history of the great discoveries which have created the new intellectual atmosphere. The flat earth has rolled itself into a spheroid. The once steadfast earth spins in its orbit around a central sun. The heavenly bodies have stretched apart into measureless distances. The six thousand years of tradition have expanded into a duration immense if not eternal. Man himself, though his duration is but a moment in comparison with that of the universe, claims an antiquity far beyond the traditional limit. The chaotic manifoldness of nature has given place to a threefold unity—a unity of substance, a unity of force, and a unity of process. All changes of matter, lifeless and living alike, are the expression of transformations of a stock of energy which suffers neither addition nor subtraction. From the nebula to man we find no break in the continuity of evolution. Meteors have clustered into suns and planets. The incandescent surface of the globe has wrinkled into continents and oceans. The simplest forms of life have developed in

endless ramification into the varied species of plants and animals, till animal life has grown divine in man himself.

And we have recognized that these changes in our thought of the universe cannot but work corresponding changes in our thought of God and of his revelation to man. We have ceased to look to the Bible for a revelation of the plan and history of the universe, or to regard the Bible as inerrant. The "carpenter God" has vanished from a universe which we have come to regard as a growth and not as a building. The metaphysical dogma of the duality of essence in human nature has been rendered uncertain by the tendencies of biological science. Evolutionary anthropology must regard the fall of man as potential rather than actual. The tendencies of scientific thought have compelled us to reject as unhistoric some of the Biblical narratives of miracle, and to regard others as more or less doubtful.

Yet these changes of belief involve the abandonment of no essential doctrine of Christianity. A Heavenly Father, a risen Saviour, an inspired and inspiring Bible, an immortal hope, are still ours.

The question which we have asked is one which thoughtful men are bound to ask. However tender and sacred the memories with which Christian faith is associated, intellectual honesty forbids the student to retain that faith, unless he can find satisfactory reasons for it. Hence each generation must have its own apologetic. If Christianity is to be the faith of all ages, its evidences must be capable of being so

presented as to establish a probability of its truth for each age, as viewed in the light of the knowledge and the dominant ideas of that age. But men who are not students of science and philosophy behold a practical reconciliation of scientific and religious thought working itself out in the life of mankind. The close of the nineteenth century was marked by the acceptance of the theories of conservation of energy and organic evolution, not as esoteric doctrines of scientific men, but as the popular belief of the masses. Yet it is equally certain that the close of the nineteenth century was marked by a decided movement in the world of thought towards the revival and strengthening of theistic and Christian faith. The generation in which we live—the generation which has accepted the doctrines of modern science—is more strongly influenced by the teachings of Christianity than any previous generation. Never has there been a time when the professed believers in Christianity were so numerous, or when the individual and the social life of mankind was so largely controlled by the spirit of Christianity. And multitudes of men and women find that the acceptance of scientific teachings in no wise disturbs their personal religious life. As men practically ceased to feel their Christian faith disturbed by the Copernican astronomy and by the geological doctrine of the antiquity of the earth, so men are practically ceasing, whether logically or illogically, to feel their Christian faith disturbed by the scientific discoveries which marked the middle of the nineteenth century.

The history of the survival of Christianity through all the changes of intellectual environment is most impressive. Other religions have found a congenial soil in a particular nation, age, or stage of intellectual culture; and have perished, or led a feeble, exotic life, beyond their natural boundaries. Christianity, by reason of its adaptation to universal humanity, thrives in every land and every age. The religion which sprang from the bosom of a nomad tribe of Asia has become the religion of the most enlightened nations of Europe. The princes of European intellect have worshiped the God of Abraham and Isaac and Jacob. Like its great apostle, Christianity is "made all things to all men," that it may "by all means save some." In an age when men were capable only of grossly anthropomorphic conceptions of Deity, the patriarchal and Mosaic revalations (which were Christianity in anticipation) glorified that anthropomorphism with a moral dignity to which the mythology of classic lands made no approach. In an age when primitive anthropomorphic conceptions give way to those of science, Christianity touches the cold, majestic marble of law, and it thrills and pulsates with divine love. The world outgrows other religions; it grows in Christianity.

The history contains a prophecy. The fact that, in changing environment, Christianity has not become extinct, but has varied and become adapted, seems to show that it possesses that plasticity—that power of adaptation to new environment—which entitles an organism to be preserved by natural selection. The

history suggests that Christianity survives because it meets the moral needs of mankind—because, whatever errors or superstitions may have been linked with it, and supposed by its foes or its friends to be integral parts of it, it contains essential truth. As long as man the finite seeks to gain inspiration from the infinite, as long as man the sinful seeks moral uplifting by the contemplation of the not himself "which makes for righteousness," so long, we may well believe, will there be need of anthropomorphic symbols for the mysterious Power "dwelling in the light which no man can approach unto, whom no man hath seen, nor can see;" and so long the truest symbols to represent a truth which, in its real essence, transcends all human expression and all human thought, will be those afforded by him who taught the world to say, "Our Father which art in heaven."

It is needless to say that no claim of certainty can be maintained in regard to Christianity as a system, or in regard to any particular doctrine of Christianity. Probability is all that can be claimed. But it is well for us to remind ourselves that it is not alone in religious matters that we must be guided by probability, and must recognize certainty as unattainable. Our discussion of the methods of science and the meaning of natural law* has made it clear to our minds that certainty in natural science is absolutely unattainable. We cannot know that the external universe has any objective existence. Our whole system of natural law may

* Page 321.

be but a castle in the air. The postulate of the uniformity of nature, upon which all our reasoning is founded, is itself utterly undemonstrable. If our postulate is admitted, the reasoning that is based upon it is at no step demonstrative, and the results can never be certain. The laws of nature which we consider most thoroughly verified may be true only approximately and within limits. Nowhere in the whole system of natural and physical science can we find certainty.

From this point of view we recognize the utter vanity of the talk which is so frequently heard, in which the solid facts of science are contrasted with the iridescent dreams of religion, and religious men are reproached for their folly in making undemonstrable beliefs the basis of their plans of life. It is well for us to remind ourselves how very narrow are the limits within which certainty is attainable. The laws of thought are certain. We may imagine a universe where space has more or less than three dimensions; but we cannot imagine a universe where a thing can be and not be at the same time. Certain, too, for each individual, is his present state of consciousness. That is the one fact which it is absolutely impossible to doubt. But, beyond the present state of consciousness and the laws of thought, all beliefs can be only in greater or less degree probable. Our personal identity, the reliability of memory and of mental faculties in general, the existence of the external world, may all be denied without self-contradiction. Alike in the common affairs of daily life, in our scientific speculations, and in the

sphere of morals and religion, we base, upon postulates which are undemonstrable, conclusions which more or less probably are more or less close approximations to the truth. And in all these spheres we act upon such beliefs as if they were certainly true. No one refuses to eat his dinner because he doubts the existence of the external world; no one refuses to accept payment of a debt because he doubts his personal identity or the validity of memory. We take medicine when we are ill, though we never can be sure that it will do us good. We build bridges, though we never can be sure that they will bear the loads that will be put upon them. We launch ships, though we never can be sure that they will reach their destined port. We advocate social and political reforms, though we never can be sure that the measures which we advocate will be useful. As Locke has well said, "He that will not stir until he infallibly knows that the business he goes about will succeed, will have but little else to do but to sit still and perish."* In like manner, it is reasonable to regulate our lives in accordance with a sense of responsibility to a God whose existence we can never demonstrate; in accordance with an expectation of a future life of which we can have no assurance until each one for himself is called to try the awful alternative of extinction or immortality; and in accordance with the doctrines and precepts of a religion for no article of whose creed we can claim more than

* Quoted (*North American Review*, vol. clxx, p. 582) by F. S. Hoffman, in article on *The Scientific Method in Theology.*

that it is more or less probably a more or less close approximation to the truth. Through a theoretical skepticism may lie our path to an intelligent practical faith. From the clear recognition of the extremely narrow limits within which certitude is attainable, we may learn the rationality and the wisdom of acting upon beliefs which are merely probable, and acting with an earnestness proportionate to the importance of the interests involved. We may learn to walk by faith more steadily, by perceiving that, in this universe in which we live, only he who is willing to walk by faith can walk at all.

The compatibility of a theoretical skepticism with a practical faith seems to me the most important practical lesson from this discussion. "What I most crave to see," said Thomas Arnold, "and what still seems to me no impossible dream, is inquiry and belief going together." In so far as that aspiration finds its fulfilment in the individual and in the church, we shall be saved alike from the dogmatism that resists all progress of thought, and from the skepticism that dooms life to aimlessness and helplessness. In the individual and in the church, the creed which is in process of formation may serve at every stage the purpose of a vigorous religious life. The engineer may rebuild a railroad bridge without stopping the running of trains. Piece by piece, the old structure is replaced by a new and stronger one; and construction keeps pace with removal. A still better illustration may be found in the growth of the body; for our religious beliefs are

not a mechanical construction but a living growth. The gristly skeleton of childhood serves the purpose of the child's life, but serves also as the mold in which is developed the bony skeleton of manhood. Every organ is at once a machine for accomplishing the purposes of the present life, and a matrix in which is developed the corresponding organ which shall be fitted for the larger work of years to come. So our childhood's conceptions of truth, imperfect as they are, serve to guide our child life, but serve also as the matrix in which are developed the larger conceptions of our manhood. In this growth of individual thought, as in the progress of the church at large, there is the continuity of organic development. Each stage, alike of individual and of collective religious life, is in vital connection with the past and the future. And so, we may reasonably hope, when at last that great metamorphosis comes to us, and we pass from this embryo state of existence to the full life of that other world, there will still be no break in the continuity of spiritual life. We shall be born into the glories of that heavenly world with eyes already prepared for its beatific vision.

It is obvious that we cannot hope in the near future to define the final form of Christian faith. The characteristic conceptions of modern science, and particularly the fruitful idea of evolution, are so novel that the human mind has not yet fully comprehended their significance and traced out all their bearings. It may or may not be within the power of the human intellect sometime to produce a complete and consistent the-

istic evolutionary philosophy. Certainly such an attempt, in the present state of knowledge and thought, would be premature. I have not attempted in this discussion a final delimitation of the territories of science and faith. I have sought only to define a *modus vivendi* which may secure peace between the two realms while surveys along their frontier are in progress. The solutions which have been proposed for the problems of religious thought in our age are only provisional. "We know in part, and we prophesy in part." But, as we have seen, our partial knowledge justifies the prophetic hope that no scientific discovery will contradict the essence of Christianity, and that the end of all questioning will be the reestablishment of faith. To me it seems unmistakable that our age of bold investigation, of truth discovered too fast to be understood and coordinated, of doubt and unrest and agonized questioning, but of moral earnestness and of loyalty to truth, is ending in a return to faith.* The pathetic story of Romanes, as told in his "Thoughts on Religion"—his twenty years of wandering in the wilderness of unbelief, and his Pisgah vision of the land of promise—is profoundly interesting as the experience of one human soul; but to me it seems yet more impressive as a type of the intellectual and spiritual life of the age which is passing away. "At evening time it shall be light." For the scientific questions of our age and of all ages touch not the central

* Van Dyke, *The Gospel for an Age of Doubt*, ch. i; Armstrong, *The Return to Faith*, in *Methodist Review*, vol. lxxviii, p. 66; Armstrong, *Transitional Eras in Thought*, pp. 107–131, 239–242.

truth of Christianity, "that God was in Christ, reconciling the world unto himself."* The inarticulate cry of universal humanity—

> "An infant crying in the night"—

finds its interpretation and its answer in Him through whom we see the Father. And to Him—"the same yesterday and to-day and forever"—the laboring and heavy-laden bring their burdens of doubt and question, as of sorrow and sin, and find rest unto their souls.

---

* II Cor., v, 19.

INDEX